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CONTENTS

		PAGE
Review		1
Sulphur Recovery		3
The Sulphur Industry of Norway		6
Prices and Trends		14
United States Sulphur		16
New Sulphur Recovery Plants at United States Oil Refineries		18
United Kingdom Sulphur		20
The Removal of Oxides of Sulphur from Flue Gases and Sulphur Recovery		22
Sulphur Consumption in Australia		25
Sulphur in Mexico		27
Elemental Sulphur in Japan		30
Company Reports :		
Tharsis Sulphur and Copper Company Limited		32
Duval Sulphur and Potash Company		33
CURRENT EVENTS :		
United Kingdom	Major Fertilizer Project	33
	Acid Plant to Close	34
	Acid Plant to Re-start	35
Eire	Exploitation of the Avoca Sulphide Ore Deposits	35
Canada	Jefferson Lake Sulphur Recovery Project	35
	Sulphuric Acid for Titanium Dioxide Plant	36
India	Sulphur Exploration	36
United States	Integrated Sulphuric Acid Plant	36
	Transfer of Chemical Construction Corporation	37
	New Sulphuric Acid Plants	38
Finland	New Sulphuric Acid Plant	38
Greece	New Fertilizer Plant	39
Turkey	New Pyrites Production	39
Japan	New Pyrites Deposits	39
Chile	Sulphur Production and Consumption—1955	39
U.S.S.R.	Investigations into Rubber Vulcanization	39
Statistical Appendix		40

INDEX TO ADVERTISERS :

Alfred Smith Ltd.	*vii*	*Huntington, Heberlein & Co., Ltd.*	*v*
Biddle Sawyer & Co., Ltd.	*ii*	*Jefferson Lake Sulphur Co.*	*vii*
Courtaulds Ltd.	*x*	*Mexican Gulf Sulphur Co.*	*ix*
Duval Sulphur & Potash Co.	*ix*	*Pan American Sulphur Co.*	*vii*
Economist Intelligence Unit	*ix*	*Ralph M. Parsons Co.*	*vi*
Econ-Verlag G.M.B.H.	*viii*	*Power Gas Corporation Ltd.*	*iii*
Ente Zolfi Italiani	*vii*	*Simon-Carves Ltd.*	*i*
Fisons Ltd.	*iv*		

Review

NOTWITHSTANDING the abundant supply of Frasch sulphur and the extensive use of sulphur in pyrites, **Sulphur Recovery** has, in the past 20 years increased its contribution to world supplies from 9¼% to 14½%, and at present it results in the production of over 2 million tons sulphur in useful form from natural, oil, coal and non-ferrous smelter gases. Recovery from natural and oil refinery gases promises the quickest expansion because production costs compare favourably with established supplies.

Sulphur recovery from coal gas and especially from fuel oil, which is playing an increasingly important part in meeting the rising power requirements of the U.K. and Western Europe, is to some extent circumscribed by technical limitations, but advances in plant and economic processes have been such that its application could be substantially increased. The recovery of sulphur from these sources would be warranted from the "clean air" aspect alone, and being enhanced by the creation of new indigenous sulphur supplies, it would, if necessary, justify promotion by subsidy. Potential reserves of sulphur contained in fuels and non-ferrous sulphide ores far exceed those of native sulphur and pyrites, and in the long term sulphur recovered from these sources could attain a position of superiority.

The **Sulphur Industry of Norway,** based on extensive deposits of iron and copper pyrites, has over the past half-century contributed over 12 million tons sulphur to world supplies. In 1955 Norway produced about 365,000 tons sulphur—in the form of 100,000 tons brimstone, 540,000 tons iron and copper pyrites and 18,000 tons sulphur in by-product sulphuric acid and liquid SO_2 recovered from smelter gases—while domestic needs, principally for sulphite pulp, sulphuric acid and rayon manufacture, totalled about 100,000 tons sulphur. The prosperity of the pyrites industry is, as in the past, determined by the level of exports to other Scandinavian countries and to Western and Eastern Europe. Because of the anticipated high cost of production at new pyrites deposits which are due to replace mines nearing exhaustion, research into economic production from pyrites of elemental sulphur, copper and iron has been intensified. If successful—and results so far are encouraging—this would further broaden the basis of the industry and lessen its dependence on pyrites export markets.

During the first quarter production in the **United States** of Frasch and recovered sulphur amounting to 1,607,706 tons receded 3% from the peak total of the previous quarter, but was 17% greater than in the first quarter 1955. Apparent sales of 1,586,336 tons, the second highest quarterly total on record, were sustained by strong demand for sulphuric acid by the steel, oil, detergent and chemical industries and from non-acid sulphur users. As a result of low fertiliser demand and the recession in automobile production, sales in March failed to show the customary strong increase.

Two major oil refiners in the U.S.A. have installed **sulphur recovery plants** to abate air pollution. These operations will add 24,000 tons sulphur annually to domestic supplies. In the U.K. the successful experimental work by the Fuel Research Station of the Department of Scientific and Industrial Research on the **Removal of Oxides of Sulphur** from power station flue gases has now been followed by the start of a major pilot plant at Nottingham power station. Although limited in application the new process offers a valuable means of promoting "clean air."

Sulphur consumption in the **United Kingdom** during the first quarter was the highest on record, amounting to 242,000 tons*,

*Excluding sulphur in anhydrite used for direct manufacture of ammonium sulphate.

8½% more than in the corresponding period of 1955. About 38¾% was met by indigenous raw materials, 22¾% by imported pyrites, and 38½% by imported brimstone. Anhydrite consumption represented 17½% of total sulphur use by the acid industry, which achieved a record output of 593,500 tons (100% H_2SO_4). The seasonal increase in acid use for fertiliser manufacture was supported by greater needs for titanium dioxide, detergents and rayon production, although the latter weakened towards the end of the quarter. The downward trend in consumption of pyrites and spent oxide occasioned mainly by the greater use of anhydrite in sulphuric acid manufacture, is likely to be accentuated as overall acid output declines during the summer.

Under the impact of rapidly rising fertiliser demand, **Australia** in 1955 used a record tonnage of 327,000 tons sulphur, 19% more than in 1954. The operation during the second half year of the new plant of Sulphuric Acid Limited based on Nairne pyrites concentrates helped to raise the tonnage of acid produced from indigenous raw materials, qualifying for the Government's sulphur bounty payment, but even so imported brimstone accounted for nearly two-thirds of the acid output of 896,000 tons (100% H_2SO_4). This year, as the result of plant conversion, indigenous resources may account for 45% of total sulphur use, compared with the Government's aim of 65%. The imminent need for new plant construction presents industry and Government with a difficult problem as on balance economic considerations favour brimstone based installations.

The pioneering period in which **Mexico** rose from obscurity to a challenging position in the world sulphur industry ended in April, when the Brady Brothers, whose discovery in the early 'forties of the sulphur domes on the Isthmus of Tehuantepec initiated this era, sold their controlling interest in Gulf Sulphur Corporation and the minority shareholding in Mexican Gulf Sulphur Company to Bear Stearns & Company, the investment house of New York, and Hudson Engineering Company of Houston. Following the successful start of operations at Gulf Sulphur Corporation's Las Salinas dome on 3rd May, this company is now producing at a daily rate of 400 tons sulphur. Pan-American Sulphur Company at Jaltipan continue producing over 2,000 tons per day, while production difficulties at Mexican Gulf Sulphur Corporation's San Cristobal dome remain unresolved. In spite of the challenge to the U.S. industry in its established markets, shipments of Mexican sulphur are as yet moving slowly and stocks are mounting. Although the industry is concerned about its marketing and production and is undoubtedly facing a difficult period in which it has to prove its reliability as a major supplier, the recent entry of U.S. financial and engineering interests underlines the widely-felt confidence in its eventual success.

Production of **Elemental Sulphur in Japan** in 1955 of 202,700 tons, although 9¼% greater than in 1954, was insufficient to meet domestic needs and token exports. Stimulated by the high level of activity in rayon and pulp manufacture total consumption rose 13% to 203,200 tons and is expected to rise further to 246,000 tons this year. The conclusion of an agreement between consumers and producers gave the latter an assured profitable price and secured their concurrence to the consumers' demand for imports which are expected to total about 20,000 tons in 1956. In view of the industry's inability to effect large-scale modernisation and rationalisation of sulphur production it has little prospect of raising output sufficiently to meet the growing domestic consumption.

The **world price** of sulphur further declined following the decision by Duval Sulphur and Potash, Texas Gulf Sulphur and Jefferson Lake Sulphur Companies to cease charging a $3 export premium. Freeport Sulphur Company brought its own prices into line earlier in February so that now, U.S. Sulphur is sold to all destinations at a basic price of $28 per ton subject only to discounts and premiums for quality.

The high cost of sea freight which rose to a new post-Korean war peak in April/May is nullifying the lower f.o.b. prices, and although at present freight rates have receded seasonally, the resumption of grain shipments and heavier coal movement across the North Atlantic later this year are expected to lead to a renewed rise in transport costs.

World supplies of elemental sulphur further increased as the result of the start of operations at the Las Salinas dome in Mexico. Current output more than meets rising demand in world markets and stocks of Mexican and Italian sulphur now total nearly 1 million tons.

SULPHUR RECOVERY

General

PERHAPS the most vexing characteristic of sulphur, which in so many aspects of its occurrence, exploitation and use displays unique features not shared by other basic raw materials, is that while it is a virtually irreplaceable industrial commodity and indeed a vital element, its widespread presence generally in small quantities in many minerals, but notably in fuels, makes it one of the most obnoxious impurities.

The large-scale industrial use of sulphur, primarily in sulphuric acid manufacture, has postulated the availability of continuous low-cost sulphur supplies in a readily convertible form, and hitherto, except for brief periods of maladjustment of supplies, global requirements have always been fully satisfied primarily by supplies of brimstone extracted from native ores and by sulphur in pyrites. By virtue of the technical simplicity of the Frasch process, brimstone so produced has shown overriding economic advantages and its sales price has become the yardstick for all other sulphurous raw materials.

The known reserves of native sulphur and sulphur in pyrites, which to-day represents

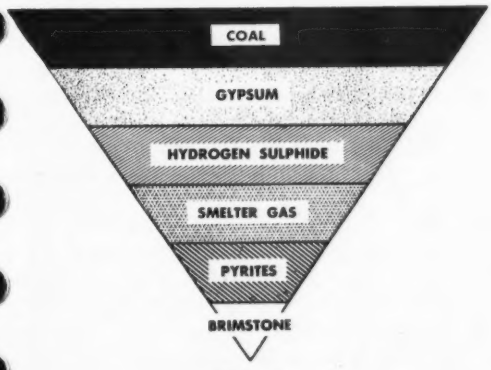


*Fig. 1.**

more than three-quarters of the total world sulphur consumption, account for only a small proportion of the total sulphur resources in the world. By far the largest potential sulphur supplies are those contained in gypsum, coal, oil, natural gas, and non-ferrous metal sulphides, and sulphur is, of course, found in many other minerals notably iron ore. In *Figure 1* their relative magnitude is shown schematically.

Except for gypsum, which, as a sulphurous raw material, is in a category by itself, the extraction of sulphur from these sources has not hitherto been undertaken specifically with a view to producing sulphur nor is this likely to be the case in the future, since it is conditioned by the deleterious effect of sulphur in the end use of the product and in the case of exit gases, by the need to minimise air pollution.

Fields of Application

Although the production of brimstone from native ores and the separation of pyrites concentrates from sulphide ores represents an extraction and recovery process—only crude pyrites, gypsum, small quantities of low grade sulphur ore and negligible occurrences of pure volcanic brimstone are used in their natural state—the term sulphur recovery applies properly to the processing of raw materials where sulphur does not represent the prime constituent or is generally present as an impurity.

The recovery of sulphur in a useful form is, in consequence, determined primarily by economic considerations and with the object that this by-product operation should not only be self-supporting but enhance the overall value of the basic raw material.

Governed by the comparative cost of established sources of sulphur supply, in particular Frasch sulphur, and by the technical advances in processes and plants, the developments in recent years have been such that sulphur recovery, which already holds an important place in the world supply scene, promises to make rapid strides in the near future.

Probably the earliest application of sulphur recovery is the manufacture of by-product sulphuric acid from the exit gases of non-ferrous metal smelters, as it combines a remedy for the serious damage which the emission of sulphurous fumes would cause to the surrounding countryside, with the low-cost manufacture of a valuable end-product. This form of sulphur recovery, practised since the

*By courtesy of the Freeport Sulphur Company.

latter half of the 19th century, only extends to less than one-half of the total of sulphur so arising but it nevertheless accounts to-day for about 8% of total world supply in the form of about one million tons sulphur in sulphuric acid and liquid SO_2.

The extraction and recovery of sulphur contained in fuels offers the greater scope but, in view of the extensive field of application which gives rise to widely differing technical problems, the results achieved, although so far not by any means negligible, are pointers to the future. This applies particularly to sulphur contained in gases resulting from the combustion of coal, where sulphur extraction ranges from the dry (ferric oxide) method in town gas purification to a variety of wet processes applicable to town gas and coke oven gas, as well as to furnace gases at coal-fired power stations.

Since one of the main criteria of sulphur recovery is its profitability, it is not surprising that the greatest advances have been recorded in connection with the purification of sour natural gas and oil refinery gases from which sulphur in the form of H_2S is readily and cheaply removed by wet catalytic processes. On the other hand sulphur extraction from the heavier oil fractions arising in oil refining, notably fuel oil, is not considered economical, although in the desulphurisation of gas oils and in liquid coking a start has been made. Similarly, the rapid expansion in the U.K. and on the Continent in the use of residual fuel oil in gas manufacture and the blending of oil with coal brings a growing volume of this potential source of sulphur within the orbit of economic recovery.

Perhaps the most difficult although undoubtedly from the point of view of air pollution a very important field for extraction and recovery is the presence of small quantities of SO_2 in large volumes of combustion gases. This applies particularly to sulphur present in iron ore, most of which is so liberated during sintering and blast furnace operations.

Sulphur in Coal Gases

During the study conference, held in London in the autumn of 1954, on the subject of the removal and recovery of sulphur from fuels, the economic and technical limitations of a variety of processes were reviewed in detail. It is significant that the largest use of sulphur in coal gases is made in the U.K. where annually over 150,000 tons sulphur in spent oxide is recovered and the bulk used in sulphuric acid manufacture. In Germany where an extensive high pressure gas grid system offers favourable conditions — and in some other Continental countries — greater use is made of wet extraction processes combined with wet-contact sulphuric acid production from H_2S. Another notable feature in Germany is the recovery, based on dry and wet processes, of sulphur in elemental form at a rate of about 70,000 tons annually.

Elsewhere, possibly with the exception of the U.S.S.R., this aspect of the coal gas industry does not make a significant contribution to sulphur supplies, and it is estimated that total free world recovery from this source is no more than 300,000 tons sulphur annually.

Sulphur in Oil

The extraction of sulphur from oil is determined by its intimate association with hydrocarbons, as the result of which it can be isolated in recoverable form only if the hydrocarbons structure of any of the natural oil fractions is altered in the course of oil refining processes. As catalytic cracking, reforming and polymerisation are essentially processes affecting the lighter petroleum fractions, containing the lesser proportion of any sulphur present in crude oil, greater recovery of sulphur which is at present lost in the heavy oil fuel and asphalt, depends on whether or not the oil industry will find a good reason for incurring the high capital expenditure which hydrogenation would demand. The production of oil from shales, bitumenous sands and gilsonite necessitates this type of treatment, and any sulphur present is eliminated as H_2S. Swedish shale oil production results in an annual recovery of 30,000 tons sulphur, while gilsonite operations in the U.S.A., which started last year, do not yield sulphur because the material now treated is very pure: the feedstock contains only ¼%S which, in the form of H_2S, is burnt off with the fuel gases. The bitumenous sand deposits of N. Alberta, where exploitation is due to start soon, are expected to yield initially at least 50,000 tons annually although this source if fully exploited for its oil content has a potential at least ten times greater.

Sulphur in Natural and Oil Refinery Gases

The favourable conditions of extraction and recovery particularly from sour natural gas has in the past ten years resulted in a sixfold increase in sulphur production from this source which at present yields over ¾ million tons annually. It is estimated that about 40% of this total originates from oil refinery gases, and although there is much room for wider application of recovery, the scope of this source is dwarfed by the potential treatment of sour natural gas. In view of excellent fuel qualities and its versatility as a chemical raw material in fertiliser, plastic and synthetic rubber manufacture, natural gas search has been intensified throughout the world, much of it highly successfully. At present only a relatively small proportion of world production — estimated at 300,000 million cubic metres annually — is in the form of sour gas and of the U.S.A. production which accounts for over 90% of the world output about one-tenth is sour. Other active producers of sour gas are Mexico, Pakistan, and Canada. Canada's development and imminent exploitation of gas resources in British Columbia and Alberta promises to make a major impact on world supplies, as up to ½ million tons sulphur annually may arise in the course of the next three years. On the basis of present plans the treatment and recovery plant of Canadian Gulf Oil Company at Pincher Creek will become the largest in the world with an annual output capacity of 307,000 tons sulphur, nearly three times greater than Texas Gulf Sulphur Company's plant at Worland, Wyoming, which is the largest to-day.

Other potential producers include France, where the gas field at Lacq is due to yield 70,000 tons sulphur annually as from 1957, and Turkey, where exploitation at the Adalaya field is about to start. The gas resources in the Middle East oilfields offer the greatest potential developments; most of the gas is sour and is at present flared off. In 1953 the Bechtel International Corporation of New York evaluated the possibility of a gas pipeline to Europe. Stimulated by the development work by W. L. Morrison & Associates of Chicago of liquefaction of natural gas by freezing and transportation in special tankers, Foreign Operations Administration made a special study of its application to the Middle East. With an estimated capital outlay of $350 million, 500 million cu. ft. of gas could be collected and transported daily—using one-fifth for liquefaction and propulsion of vessels—at a cost equivalent to U.S. cents 43 per 1,000 cu. ft. c.i.f. London, a figure substantially below the cost of U.K. coal gas.

The application in the U.S.A. of this method of gas transportation is on the point of starting and a U.S. Government agency is now examining it with a view to satisfying shipping regulations. The economic use of the Middle East gas resources with the consequent large-scale arising of sulphur, may thus be realised in the near future.

Other Sources

Promising developments are on the point of realisation at Larderello, Central Italy, in the economic extraction of H_2S from geothermal steam. This method could find application in Iceland, New Zealand and Japan, where similar phenomena occur.

The use of lignite in gas manufacture, as projected at Morwell, Australia, Ptolemais, Greece, and Neyveli, Madras, and its use as raw material in ammonia synthesis, represents another potential source which is already being exploited in Finland and Spain. In addition to the prime sources of sulphur recovery, there is a wide field of possible application of recovery or re-use of sulphur which is at present wasted in industrial processes based on the use of sulphuric acid. Already in some instances, e.g., sludge acid, impressive progress has been made.

Summary

Notwithstanding the abundant supply of of low cost Frasch sulphur and the extensive use of sulphur in pyrites, sulphur recovery is assuming greater importance in world supplies. Representing an increase of nearly 1½ million tons sulphur, its share has grown from 9¼% in 1934 to 14½% in 1955, and at present the rising trend is due largely to developments in recovery from natural gas. Its wider application, notably to other fuels, although to some extent circumscribed by technical limitation, is to-day obstructed largely by economic considerations.

Air pollution is in itself a matter of growing concern in all industrial countries and the abatement of the sulphur nuisance offers

attractive rewards by the creation of new sources of indigenous sulphur supplies. Although in many instances sulphur extraction may only be marginal or even economically unattractive it would be warranted from the "clean air" aspects alone and its application could justifiably, if necessary, be promoted by subsidy. An important factor in this respect is the increasing use of oil to meet rising power requirements; in the case of the United Kingdom and most European countries it will be derived from the Middle East and therefore contain substantially more sulphur than fuels used hitherto. As a competitive source of supply, recovery will inevitably find increasing application as a means of reducing dependence on imported sulphur. Any reduction in the availability of low cost supplies from established sources coupled with the incidence of rising freights should enhance the importance of recovery and could promote it to a position of superiority.

THE SULPHUR INDUSTRY OF NORWAY

General

ONE of the most striking features of the Norwegian sulphur industry is the balanced pattern of consumption which springs from the versatility of the country's output of sulphur in various forms.

The principal sulphurous raw materials are iron and copper pyrites, which occur in abundance in crude form and in conjunction with copper and other sulphide minerals. The systematic exploitation of pyrites dates from the last decade of the 19th century although a few old-established copper mines are reported to have produced pyrites as early as 1865. The industry, which in the late 1930's reached an output level in excess of one million tons pyrites annually, owes its expansion primarily to the needs of the sulphite pulp and the sulphuric acid industries of Scandinavia and Western Europe; prior to World War II Norway's status as a pyrites exporter was only exceeded by Spain.

The development in the late twenties by Orkla, the leading pyrites producer, of a process for the production of elemental sulphur from pyrites, established Norway as an important brimstone supplier, while more recently the use of sulphur in exit gases at zinc and nickel smelters has led to by-product sulphuric acid and liquid sulphur dioxide manufacture.

In 1955 total sulphur production amounted to about 365,000* tons of which about 67½% was in the form of iron and copper pyrites and pyrites concentrates, 27½% as elemental sulphur and 5% recovered from smelter gases.

Domestic consumption, which has grown rapidly in the past ten years, amounted to about 101,000 tons in 1955. Requirements of the sulphite pulp industry, the sixth largest in the world, account for about 56% of total usage, sulphuric acid manufacture for 34%, and other uses, principally CS_2 for rayon manufacture and use of pyrites as a metallurgical flux, for the balance of 10%. Notwithstanding the significant expansion of the domestic requirements which over the past 20 years have more than doubled, the Norwegian sulphur industry depends on exports. Primarily for geographical reasons, which have favoured the integration of the respective industries, a large part of Norway's exports of pyrites and sulphur goes to the other Scandinavian countries, notably Sweden. Germany though still an important market for pyrites, in particular cupreous ore, is now less dominant than prior to the war, while Eastern European countries now take an increasing share.

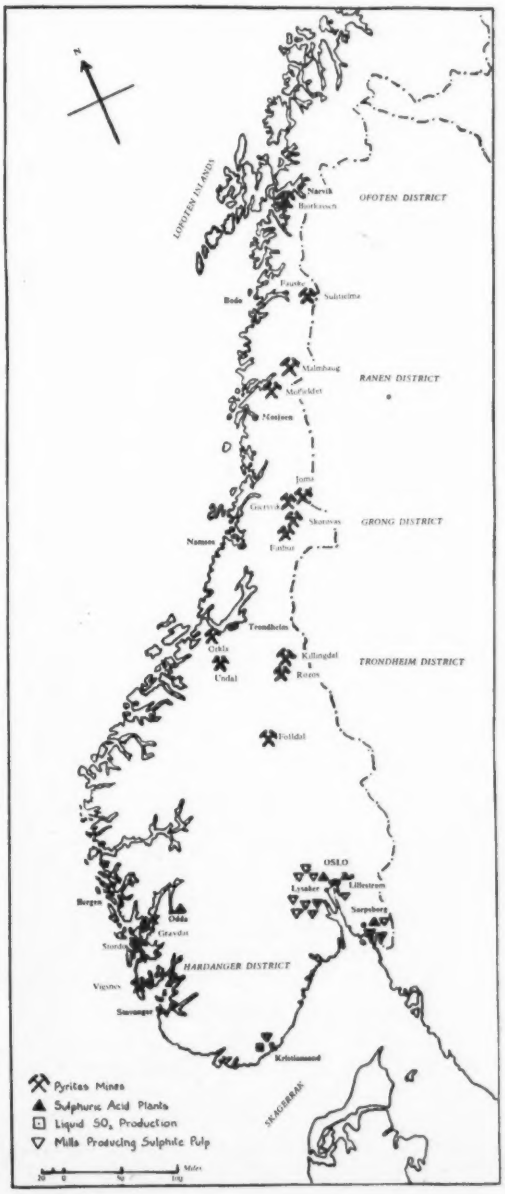
PRODUCTION

Pyrites

Based on deposits extending northward from Stavanger beyond the Arctic Circle, the output of the pyrites industry in 1955 amounted to 831,000 tons pyrites, the highest post-war total and 4½% more than 1954. It was contributed by thirteen producers, of whom seven are prominently engaged in the production of non-ferrous metal concentrates, notably copper, and one is primarily an iron ore producer whose ore treatment operations also yield a pyrites concentrate. The remaining five, mining exclusively iron and copper pyrites of varying grades, account for over two-thirds of the total output, and include Orkla Grube A/B, still the largest individual producer, and Electrokemisk A/S, now the principal pyrites exporter. The development by the latter of the Skorovas

*All quantities in metric tons.

deposit where production started late in 1952 was intended to compensate for the reduced output at Orkla's Lökken mine, most of which in recent years has been devoted to supplying the needs of the company's smelter for the production of elemental sulphur and copper matte.



Although like several other prominent producers Orkla Grube A/B have cut back output in order to extend the useful life of the mine, the limitation of ore reserves applies only to individual deposits and not to the country as a whole. Norway is estimated to have some 50 million tons pyrites in known deposits, the most extensive of which are situated in the Grong district of North Trondelag.

With the notable exception of Orkla, nearly all other producers have to subject at least part of their ore output to a treatment process to obtain a commercial grade pyrite. Ore beneficiation methods include the production of concentrates by selective flotation of mixed metal sulphide ores, separation by jig and table, washing and hand picking. In consequence the various producers' output ranges from 39% to 49% S, and shows widely differing non-ferrous metal and iron contents, but with few exceptions the use of Norwegian pyrites is favoured on account of their good roasting qualities and the absence of arsenic from the ore.

ORKLA GRUBE A/B

Situated at Meldal some 30 miles inland from the head of Trondheim Fjord, the Lökken mine is a massive deposit of high-cupreous pyrites, which in view of the stability of the ore body and the hardness of ore permits excavation in large chambers. At present ore is extracted at an annual rate of about 350,000 tons useful pyrites, little more than one-half of the peak output in the 1930's. This rate of production was determined about five years ago, when due to the rapid depletion of reserves, the company decided to devote the bulk of its output to sulphur and copper production, whereas until then it had provided the major part of Norway's pyrites exports. It is estimated that available reserves amount to about 6½ million tons ore, representing a useful life of about 12-14 years. Of the current output about 300,000 tons pyrites containing 41-42% S, 1.9% Cu, are supplied to the smelter, and the balance of up to 70,000 tons, containing 40-41% S, 2.1% Cu ground and screened to 6mm., is exported. Sweden and Western Germany are traditional users of this ore, as both countries have cinders treatment facilities where the high copper values can be extracted.

ELEKTROKEMISK A/S

The company's Skorovas deposit containing about 7 million tons of ore is part of the rich Grong pyrites field which represents Norway's main ore reserve. Although the concession dates back to 1934, intensive development work only started after the war when the project was made possible by Marshall Aid funds and State guaranteed loans. Transport and ore treatment presented major difficulties; the adverse nature of the terrain between mine and loading installations some 45 kms. distant necessitated the construction of an aerial ropeway which when first completed lacked stability in high winds and had to be reinforced by closer placing of supporting masts. The complex nature of the fine grained Grong pyrites entailed extensive trials but satisfactory treatment was finally achieved in full-scale operation. The flotation plant, which was started late in 1952, has an annual capacity of 150,000 tons high grade concentrates, part cupreous containing 47-48% S, 0.8% Cu, part low cupreous containing 48-49% S, O.4% Cu.

SULITJELMA GRUBER A/S

Exploiting five sulphide ore deposits, extending over an area of over six miles square, the company are prominently engaged in the production of copper and zinc concentrates which together with pyrites concentrates are obtained by selective flotation of ore containing about 1½% copper, 1% zinc, 18-22% sulphur, and 45% iron. Crude ore output at an annual rate of about ¼ million tons yields approximately:—

60,000 tons flotation pyrites containing 0.2 Cu, 49½% S
2,500 tons cupreous fines containing 4-5% Cu, 44% S
2,000 tons zinc concentrates containing 48-50% Zn, 35% S
15,000 tons copper concentrates containing 23-25% Cu, 36% S

The company's flotation plant and copper smelter are situated in the centre of the mining area, some 10 miles from the Swedish border, and transport of the output of pyrites and other products to loading installations at Finneid entails movement by mineral railway to Sjönsta, and thence by lighters across Lake Ovre Vand and finally by ropeway across a narrow neck of land to the storage at the loading pier on Fauske Fjord. Although proved reserves amount to less than four million tons ore, the recent discovery of large possible reserves is said to safeguard the future of operations for many years. As the result of participating in a local hydro-electric scheme, the company can now adequately meet the power requirements of the mines, treatment plant and smelter, where previously output was hampered by recurrent shortages.

Installations at Sulitjelma

A/S BJORKAASEN GRUBER

Situated on the south side of Ofoten Fjord, Bjorkaasen is the northernmost pyrites mine in Norway. Mainly on account of shrinking reserves, ore extraction was not expanded after the war and has remained restricted to an annual rate of 130,000 tons crude ore containing 30% S, 0.5% Cu, 0.7 Zn, representing one-half of mine and plant capacity. Differential flotation is applied to about 40% of the crude ore output, while 60% is beneficiated by handpicking, followed by jig and table washing. The company's saleable output, which is carried by a small mineral railway to Ballangen for shipment, is approximately as follows:—

55,000 tons washed ore containing 48% S, 0.3% Cu
10,000 tons flotation concentrates containing 46-47% S
1,500 tons copper concentrates containing 19-20% Cu
500 tons zinc concentrates containing 46-48% Zn

A/S STORDO KISGRUBER

Formerly associated with Zellstoff-fabrik Waldhof, the German pulp and viscose concern, the mine is now under State ownership. Current ore output is restricted to 160,000 tons annually, partly because of damage sustained during the war, but also due to faulting in the ore body. The ore mined is a low-grade

(21% S) iron pyrite free from non-ferrous metals and arsenic. Jig and table separation yields about 50,000 tons pyrites containing 39% S and handpicking about 5,000 tons, containing 40% S. The tailings, containing up to 23% S, are used in road construction.

FOLLDAL VERK A/S

The company, which in 1954 was acquired by A/S Borregaard, one of the principal chemicals and pulp manufacturers in Norway, operates a group of lenticular deposits of mixed sulphide ore, containing about 25-27% S, 0.8-1% Cu, 2½% Zn, 25% Fe. Differential flotation yields approximately:—

40,000 tons flotation concentrates containing 46% S
3,500 tons copper concentrates containing 18% Cu
3,000 tons zinc concentrates containing 46% Zn

Folldal is the largest supplier of pyrites to the domestic market.

Lesser producers include:—

A/S Vigsnes Kobberverk

Formerly one of the major producers, output is now reduced due to depletion of reserves to about 50,000 tons annually of sulphide ore, containing about 25% S, ½% copper, 1½% zinc, and about 5,000 tons pyrites containing 44% S. Differential flotation yields 20,000 tons pyrites concentrates (47½% S), copper and zinc concentrates, and a small quantity of pyritic tailing (43½% S).

Killingdal Grubeselskab

The company's mine near Reitan in Central Norway is a deposit of high cupreous pyrites with known reserves of about ½ million tons. Part of the ore production, 9,250 tons in 1955, was shipped as pyrites fines containing 43-44% S and 1.8% Cu. The balance of 16,700 tons was treated in the company's flotation plant built at Trondheim in 1951, to yield 11,500 tons pyrites concentrates (49% S), 1,300 tons zinc concentrates (49% Zn) and 970 tons copper concentrates (20% Cu). Mine capacity is reported to be about 40,000 tons ore per annum.

A/S Undal Vaerks Nye Interressantskab

The company exploits a cupreous pyrites deposit situated at Rennebu, about 15 miles south of Orkla's Lökken mine. Until recently part of their output was shipped in the form of cupreous fines, containing about 39% S, part treated in Killingdal's flotation plant. Last year the entire output was subjected to flotation yielding 15,000 tons pyrites concentrates with 46½% S, and projected output this year is 17,000 tons.

Fosdalens Bergverks A/S

The company is the second largest iron ore producer in Norway. Its crude ore output of over ½ million tons is beneficiated to a 65% low phosphorous iron concentrate and this process yields about 12,000 tons pyrites concentrate containing 48½-49½% sulphur, 3% iron.

Bergverkselskapet Nord-Norge A/S

The company exploits a group of mixed sulphide ore deposits, the output of which together with that of the A/S Bleikvassli Gruber is treated in Nord-Norge's flotation plant at Andfiska. Annual output is about 7,000 tons pyrites concentrates containing 47½% S, as well as lead and zinc concentrates.

Gravdal Grubeselskap

The output of about 8,000 tons low grade pyrites is handpicked to yield 6,000 tons crude ore containing 40% S, ¾% Cu.

A/S Roros Kobberverk

Primarily a copper producer, the company extracts about 50,000 tons high cupreous ore which in the course of flotation yields about 4,000 tons copper concentrate and about 2,000 tons pyrite concentrate (37% S).

Grong

This extensive pyrites field contains the bulk of untapped pyrites reserves in Norway. Estimated at 20-30 million tons, it is owned by A/S Grong Gruber, a State-controlled company. It is reported that plans are at present under consideration for its reorganisation and re-financing, and an official statement may be issued shortly.

Present development plans concern the exploitation of the Gjersvik and Joma deposits which contain cupreous pyrite, complex and fine grained like all the ore in this district. The smaller Gjersvik deposit containing only about 1½ million tons ore, is likely to be exploited first probably at an annual rate of 100,000 tons, and initially the output is expected to be treated in a flotation plant. Intensive research is understood to be in progress with a view to developing an alternate method of ore beneficiation which would result in the production of elemental sulphur, copper and iron. Owing to adverse transport conditions, and the difficulties already experienced in treating Grong pyrites by flotation, the

exploitation of the large Joma deposit which has proved reserves of 15 million tons may be deferred until the beneficiation problem has been solved.

Last year the Norwegian State Laboratory was granted British Patent E.P. 726,216, which covers the production of elemental sulphur and ferric oxide from iron sulphides. Ore in fluidised state is roasted in the first zone of a furnace with a mixture of sulphur dioxide and oxygen to yield ferrosoferric oxide, sulphur and sulphur dioxide. The sulphur is removed and the sulphur dioxide replenished with technical oxygen, is recycled to the second zone of the furnace to fluidise and oxidise the ferrosoferric oxide fed thereto, the gases then being passed to the first zone and the ferric oxide formed withdrawn. The amount of oxygen employed is such as to maintain constant the quantity of sulphur dioxide circulating, this being from 3 to 20 times the quantity formed by the reaction of the oxygen and ferrous sulphide. Reaction temperature should be preferably 900°-1,000° C., avoiding sintering.

Based on this and further research a combined distillation and roasting process is now said to be favoured. Production of SO_3 is foreseen by coke oven gas from Svalbard coal, which hitherto failed to find an adequate outlet in Norway due to limited uses for gas.

In April, the Storting authorised the expenditure of Kroner 1.8 million from research funds for the construction of an adit at Joma with the object of obtaining sizeable representative samples which it is hoped will speed the research programme to successful results.

Elemental Sulphur

Developed by Mr. N. E. Lenander, former managing director of Orkla and director of Mason & Barry Limited, the "Orkla-process" for the recovery of elemental sulphur as by-product of copper smelting of cupreous pyrites was first operated in a small blast furnace at Lökken in 1928. Its successful application, which was the result of 10 years' development work initially with Professor Pedersen of Lilleby and later with engineers of Mason & Barry Limited and the Rio Tinto Company Limited, led to the installation in 1932 of a large-scale plant at Thamshavn, comprising four blast furnaces, and of similar, though smaller, plants adapted to the idiosyncrasies of the local pyrites at the above-named companies' mines in Portugal and Spain.

The principle of the process is to smelt sulphide ore to matte in the absence of oxygen and with an excess of coke in the smelting charge. The first condition was achieved by fitting a closed top to an ordinary blast furnace with the result that the loose sulphur atom in pyrites was turned to sulphur vapour and did not burn, whereas the coke reduced the SO_2 during its ascent through the furnace charge. As at an economic balance of carbon/pyrites some SO_2 remains unreduced and escapes with the exit gases which also contain COS, CS_2, and H_2S, these are subjected to catalysis in a Claus type furnace which permits the sulphur so contained to be extracted thereby increasing recovery from about 60% to 82%. Only non-arsenical pyrites, such as Orkla, permit this step in recovery, and the Spanish and Portuguese operations are in consequence less favourable.

The following is a typical materials balance, represented by the 1953 results at the Thamshavn plant, which is run by Orkla Metal A/S:—

Charge:	*Metric tons*	*Yield*	*Metric tons*	
Pyrites 41.74% S, 1.89% Cu ...	290,400	Copper matte	13,246	33.87% Cu
Limestone	22,241	Iron slag	34,103	43% Fe
Quartz	50,519	Elemental sulphur	103,335	99.47% S
Coke	38,245	Appx. Impurities 0.2% Ash, 0.015% As., 0.015% Se.		

Since 1950 sulphur output has been consistently at a level of about 100,000 tons annually; the 1955 output amounted to 100,446 tons.

Orkla Metal A/S are reported to have developed recently an electrolytic process which permits the production of very pure iron instead of the conventional iron slag. No details are as yet available although it is believed that this process may also improve copper recovery and possibly also the recovery of sulphur. Due to its heavy requirements of electric power its application may have to be deferred until cheap power supplies in Central Norway are adequate to permit economic production.

Smelter Gases

The use of sulphur in exit gases of non-ferrous metal smelters provides an economic supply of by-product sulphuric acid and liquid SO_2 which in 1955 represented the equivalent use of about 18,500 tons brimstone.

At the zinc smelter at Odda of Det Norske Zinkkompani A/S, which is closely associated with Cie. Royale Asturienne des Mines, SO_2 gases from the roasting of zinc concentrates predominantly of Swedish, Spanish, Canadian and Australian origin, are converted to sulphuric acid in a Petersen tower plant which has a daily capacity of 150 tons (100% H_2SO_4). In 1955 roasting of about 75,000 tons concentrates resulted in the manufacture of 42,443 tons acid, the bulk of which is captive.

At the Kristiansand works of Falconbridge Nikkelverk A/S, sulphur in exit gases from the roasting of copper/nickel concentrates, mostly of Canadian origin, is used in the manufacture of liquid SO_2.

In recent years, output, the bulk of which is being supplied to sulphite pulp manufacturers, was as follows:—

1953	—	5,057 tons
1954	—	6,123 "
1955	—	6,905 "

Production to an annual rate of 12,000 tons is due to start this summer.

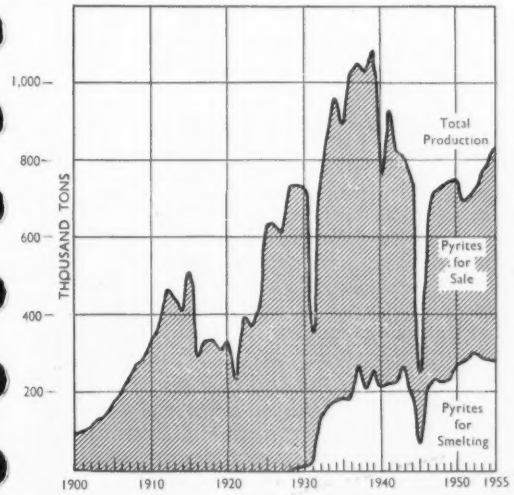


Fig. 2. Pyrites Production.

Summary

It is estimated that in 1955 sulphur production in the form of pyrites and recovered from smelter gases totalled 395,000 tons. As about 290,000 tons (35%) of the total pyrites output of 831,600 tons was used in the manufacture of elemental sulphur, in the course of which some of the sulphur is lost, net production is estimated as follows:—

Production	*tons sulphur*
Pyrites for domestic use and export	246,000
Elemental sulphur	100,446
By-product acid and liquid SO_2 ...	18,500
Total ...	365,000

CONSUMPTION

The expansion of Norway's sulphur requirements, which in the past five years have risen by 40%, is attributable to the increased activity of the sulphite pulp industry and to the growth of sulphuric acid output to meet the needs of the fertiliser, rayon and other industries. In 1955 consumption, which is wholly met from domestic resources, is estimated to have totalled 101,000 tons, of which 25¾% was in the form of elemental sulphur, 56% as sulphur in pyrites, and 18¼% as by-product acid and liquid SO_2 recovered from smelter gases. The pattern of consumption is believed to be as follows:—

Sulphur in:	*Sulphuric acid*	*Pulp*	*Rayon*	*Other*	*Total*
	thousand tons				
Brimstone ...	1	19	4	2	26
Pyrites ...	19	33		5	57
Smelter gases	14	4			18
	34	56	4	7	101

Sulphite Pulp

Represented by fourteen individual producers, the industry is the largest single sulphur user, accounting for about 56,000 tons sulphur in various forms. The majority of the larger producers, such as A/S Borregaard, A/S Krogstad Cellulosefabrik, A/S Tofte Cellulosefabrik, A/S Union, roast pyrites and about 60% of the industry's SO_2 requirements are met exclusively from this source of supply, although most plants have standby sulphur burners . About one-third uses elemental sulphur and a small number, amongst whom Hunsfos Fabrikker is prominent, cover their needs by purchasing liquid SO_2.

It is as yet uncertain how the increased supply of liquid SO_2 will affect the industry,

although it is probable that this ready supply will be most attractive to smaller producers especially those roasting pyrites.

Viscose Rayon

Of the two viscose rayon manufacturers in Norway, Kunstsilkefabrikken A/S at Notodden is engaged in filament manufacture, whilst A/S Borregaard at Sarpsborg manufacture staple fibre. The entire CS_2 requirements of the industry are manufactured by A/S Borregaard which consumes about 4,000 tons elemental sulphur annually for this purpose. The company also manufactures its own acid requirements, but Kunstsilkefabrikken A/S, who obtain their CS_2 needs from A/S Borregaard, also procure all their acid needs from outside sources.

Sulphuric Acid

Production of sulphuric acid in 1955 amounted to about 93,000 tons, 5,000 tons greater than the previous year and about 65% greater than in 1950 when acid output amounted to 57,000 tons. Nearly all acid produced is captive and imports of sulphuric acid have steadily decreased until 1955 when Norway became self-sufficient in acid supplies. Approximately 45% of acid supplies are consumed in the manufacture of fertilizers, about 30% by the textile industry, the remainder being used in the manufacture of explosives, paper and by other industries.

Total installed capacity at the undermentioned plants is about 140,000 metric tons (100% H_2SO_4). On the basis of available information production of sulphuric acid during the years 1950-1955 has been as follows:—

	1950	*1951*	*1952*	*1953*	*1954*	*1955*
			thousand tons			
Det Norske Zinkkompani A/S ...	21.6	29.1	30.3	30.3	40.7	42.4
Lysaker Kemiske A/S	25.7	26.8	24.1	27.5	22.4	19.5
Norsk Spraengstofindustri A/S ...	9.3	11.9	12.8	13.4	13.9	14.5
A/S Borregaard					11.0	17.0
Total Sulphuric Acid ...	57.0	67.8	67.2	70.9	88.0	93.4

The Det Norske Zinkkompani of Odda accounts for nearly half of Norway's sulphuric acid production with an output in 1955 of 42,443 tons (100% H_2SO_4) by-product sulphuric acid resulting from the roasting of blende for zinc production. The gas is converted in a Petersen tower which has a daily capacity of 150 metric tons. Over half of the acid produced is used in the company's superphosphate plant which has an annual capacity of 95,000 tons. In recent years this has been operating between 50-75% of capacity except in 1954 when it operated at full capacity. A new triple superphosphate plant is due to be completed at the end of this year; the phosphoric acid section designed by Dorr-Oliver Inc. will treat up to 200 tons phosphate rock per day with sulphuric acid. Consumption of acid at the zinc plant reached a record figure of 10,600 tons in 1952, then fell away sharply the next two years and in 1955 totalled 8,700 tons.

The next largest acid producer is Lysaker Kemiske A/S with an installed capacity of 45,000 tons divided between a contact plant of 70 tons per day and a Petersen tower system capable of producing 60 tons per day. Based on the use of 14,000 tons pyrites (47½% S) and a small quantity of elemental sulphur, acid production in 1955 amounted to 19,500 tons compared with the record total of 27,500 tons in 1953. Pyrites roasting and sulphur burning capacity is adequate to permit both plants to operate simultaneously.

To meet the large sulphuric acid requirements of their staple rayon mill A/S Borregaard of Sarpsborg installed early in 1954 a pyrites roasting unit and a contact acid plant with an annual capacity of 25,000 tons (100% H_2SO_4). Pyrites are obtained from the Folldal mine in which the company holds a substantial share.

Rayon staple fibre manufacture accounts for the bulk of the company's acid needs, which including the small quantity needed for the drying of chlorine, amounted to 15,000-17,000 tons annually over the period 1950-1955.

Norsk Spraengstofindustri A/S is Norway's smallest acid producer, and its output at present is about 14,000 tons. The acid is used mainly in the manufacture of various types of explosives and by its subsidiary company, Gullaug Kjemiske Fabrikker, who have plants at Lillestrom and Gullaug for the manufacture of paint and synthetic varnish resins and varnish nitrocellulose.

Greater use of installed acid capacity is foreseen to meet rising requirements for established uses, and in the case of A/S Borregaard also for new aluminium sulphate production. New acid capacity in the form of a 50,000 t.p.a. contact plant is planned by Norsk Hydro, one of the largest synthetic nitrogen producers in the world, and A/S Aardal and Sundal Verk of Oslo may be building a new acid plant in connection with the manufacture of synthetic cryolite.

TRADE AND PRICES

Pyrites

In view of the limited domestic outlet, export markets remain the principal factor determining the level of production of Norway's pyrites industry. In 1955 Orkla's own consumption was about 290,000 tons pyrites for sulphur and copper production and domestic users consumed about 120,000 tons, of which about one-half was supplied by Björkaasen and Folldal. As the result of brisk export demand the balance of new production, representing a little over one-half of total output, had to be augmented by 60,000 tons from stock, and total exports in 1955 of 472,654 tons*, 12% greater than 1954, were the highest since the war.

Norway's proximity to major markets represents a telling advantage and the supply of cupreous pyrites further enhances her position as a supplier to Sweden and Germany, where the resultant residues are in demand by the cinder extraction plants. Denmark is a traditional market, and Norway has consolidated her position as supplier to Eastern Germany, Poland and Czechoslovakia, which account for up to 30% of annual exports.

In 1955 the average export value of pyrites was Norwegian Kroner 105.50 (£5 5s. 6d.) per metric ton, but on account of varying grades and qualities this is not strictly comparable with the price of other European pyrites.

Brimstone

In 1955 Norway's exports of 79,050 tons were almost exclusively confined to Sweden and Finland, as their increased requirements and those of the home market precluded exports elsewhere. In previous years Norwegian sulphur was regularly supplied to Western Europe and frequently to Australia. The average export price in 1955 was N. Kroner 272 (£13 12s.).

CONCLUSION

The Norwegian sulphur industry, which during the past half-century has contributed over 12 million tons sulphur to world supplies, although not quite as prominent as before World War II, continues to hold an important position as producer of pyrites and elemental sulphur and as supplier to the sulphite pulp and sulphuric acid industries of Scandinavia, Western and Eastern Europe. As the result of the close co-operation between producers, through their trade association the Norske Svovelkisprodusenters Forening, and the Government, the development of the country's extensive ore reserves is closely related to established production facilities and to disposal facilities in export markets, which as in the past determine the industry's prosperity and level of activities. Although Norway enjoys many advantages compared with other European producers the industry is alive to the adverse trend in pyrites usage, which has recently also manifiested itself in Sweden, one of her oldest and most important markets.

The industry is a fairly high cost producer partly on account of diminishing reserves and output at some of the older mines. The imminent exploitation of the country's principal reserves in the Grong district is also likely to entail a high cost of production owing to adverse transport conditions and difficulties in treating the complex ore. Intensive research is centred on the use of pyrites as raw material for the economic production of elemental sulphur, copper and iron, and if successful would appreciably reduce the industry's dependence on pyrites export markets. Results so far are encouraging and hold promise of enhancing Norway's position in relation to other European pyrites producers.

*For details see Statistical Appendix.

Prices and Trends

Prices

ALTHOUGH during the past three months world prices have further weakened the spectacular rise in sea freights, which in April culminated at a level not reached since the Korean war peak in 1951*, nullified the lower f.o.b. costs and caused delivered costs of cargoes, for which charters were concluded during the early part of the second quarter, to show an increase varying between 3% and 5%. The reduction was occasioned by the realignment of the price policies of the U.S. exporters of sulphur. Following the lead given by the Freeport Sulphur Company, who in February eliminated the differential between the domestic and export prices, Texas Gulf Sulphur on 20th April similarly reduced the company's export prices by $3 and now charge $26.50 per ton f.a.s. for off-colour and $28 for bright sulphur to all destinations. Jefferson Lake Sulphur Company and Duval Sulphur Company also made similar price adjustments. To sum up, U.S. Frasch sulphur is now sold to all destinations at $28 per ton f.o.b. subject only to quality discounts or premiums which give individual producers flexibility in the increasingly competitive market. In spite of the conflicting trends in first quarter earnings of the two major companies—Texas Gulf Sulphur dropped $1½ million (17%) compared with the corresponding period 1955, while Freeport Sulphur, although operating at the lowered export price, showed a $0.9 million (33%) increase—it would be wrong to infer that either company intends or expects to attract the other's customers by an alteration in price policy. It is believed that Freeport's decision, made on the assessment of a weak statistical position in world markets mainly on account of Mexican competition at substantially lower prices, was accepted as sound by the other U.S. exporters who by tradition are anxious to present to the world a uniform price front.

Price indications of Mexican sulphur in recent months tend to be confined to the lower limit of the now established range of $25 to $26.50 f.o.b. It is understood that in anticipation of being able to supply bright sulphur from the new treatment plant, Pan-American Sulphur Company are offering this grade at $26.50. Gulf Sulphur Corporation although in production have not yet tested the market with offers.

The Ente Zolfi Italiani has maintained the price level of Gialla Inferiore (99% sulphur), and of Buona Sicilia (98% sulphur), which form the bulk of exports, at L23,000-24,000 per metric ton, with special discounts in some markets where the freight advantage over U.S. and Mexican supplies is not so marked. Italian sulphur has in spite of the reduction of U.S. export prices improved its competitive position as the incidence of higher freights was much less pronounced in the Mediterranean.

For the present the Chilean sulphur price position remains unchanged, but in view of the recent establishment of a free exchange system the outlook is obscure. There is a balance of outstanding sulphur shipments against compensatory commodity transactions for which licences are still valid and not yet fulfilled—notably for lorries and cars. It is understood that the Government will authorise the execution of these transactions, up to the end of this year, but it is not clear whether this extension refers to new transactions or is merely a time limit for the execution of existing engagements. At the present level of free exchange rates —reported to be U.S. $1 = Chilean $800 and £ sterling 1 = Chilean $1,400—Chilean sulphur could be profitably shipped at under U.S. $20 per ton f.o.b.

The following table shows a comparison of prices of sulphur of different origin. F.o.b. prices and freights are based on recent quotations:

	f.o.b. Country of origin	*Freight to‡ U.K.*	*per ton c.i.f. U.K.*
U.S.A.	$26.50-28	105s.	£14¾-15¼
Mexico	$25-26.50	105s.	£14¼-14¾
Italy/Sicily	L.23,000	65s.	£16⅝
Chile	U.S. $18-22	135s.	£13¼-14⅝
Ecuador	U.S. $42	135s.	£21¾
Canada	$20 ex-works	130s.	£19¼

‡Based on bulk cargoes of 5,000-6,000 tons on the usual sulphur terms of chartering.

*The U.K. Chamber of Shipping single voyage index reached 162.2 (1952=100, 1951–157.1)

Pyrites

Prices of European pyrites for delivery during the second half of this year have been reduced slightly, following the decision of the major Spanish producers to cut the export price by 5s. to a level of £5 per metric ton f.o.b. This decision appears to have been made possible by the statutory increase of the domestic pyrite price amounting to Pesetas 30 per metric ton which was authorised by the Spanish Government to help compensate producers for the earlier official increase in basic wages. The first increase in the domestic price since 1950 it is, in terms of the export exchange rate for pyrites, equivalent to about 10s., and applies to about one-third of the major producers' total shipments.

Other European producers, whose prices were generally below the level of Spanish export prices, are also reported to have made a reduction but only to the extent of 2s.-3s. per metric ton. Although the range of f.o.b. prices, £4 10s. to £5 per metric ton represents a reduction of 5%, this benefit to consumers is likely to be nullified by the impact on residue values of the fall in copper prices and by the increased level of freights.

Freights

Freight rates in general, but especially in the N. Atlantic, which had been consistently firm early this year on account of the heavy coal shipments, rose steeply in April and May as the result of a strong revival in grain trading. Sulphur freights followed the general trend and rates from the Gulf to the United Kingdom and the Continent at one time reached 130s. The reaction which set in early in June was mainly due to seasonal influences as the demand for grain tonnage abated, although the anticipated reduction of coal shipments in July, when output is usually cut by holidays, was a major contributory factor. Sulphur charters from the Gulf for the U.K. and Continent receded to 110s.-115s. and at the end of June single voyages could be fixed at 105s. and less. It is generally expected that in about 6-8 weeks with the resumption of N. Atlantic grain shipments and the heavier demand for coal tonnage, freight rates will once more rise and could reach May levels. Mediterranean freights for pyrites and sulphur rose correspondingly, but the fluctuation was less pronounced and at present they appear to be firmer than North Atlantic rates. Current chartering is securing handy sized vessels from Huelva to N.W. Europe at 44s.

Supplies

Production in the U.S.A. of Frasch and recovered sulphur, which is receding from the peak levels of the early months of the year in conformity with the slackened demand—mainly on account of the heavy drop in requirements of the fertiliser industry and the slight decline in rayon, steel, and chemical end uses—remains more than adequate to meet domestic and export needs.

It is now widely expected that during the third quarter industrial activity should once more speed up, leading to greater sulphur and acid needs. In the meantime, arrivals of Mexican sulphur are making slight inroads in the U.S. domestic market. U.S. producers, aided by recent price reductions, are strongly promoting export sales.

Output of Mexican sulphur, in spite of production difficulties by Mexican Gulf Sulphur Company, is rising, on account of greater output by Pan American Sulphur Company, which is reported to be consistently producing more than 2,000 tons per day. Successful steaming of the Salinas dome of Gulf Sulphur Corporation has as from the 3rd May added about 400 tons brimstone to the daily output in Mexico. Pending the conclusion of sales arrangements, Gulf Sulphur Corporation is reported to be placing a part of the new production at the disposal of Mexican Gulf, to enable the latter to meet engagements. Mexican export shipments are moving very slowly and stocks at mines are mounting.

In Italy deliveries to domestic users and export markets have shown little change, but they are insufficient to reduce the stockpile, which still exceeds 300,000 tons. Dissatisfaction by producers with the Government's plans to aid the industry, expressed at a meeting in mid-June, may once more lead to an interruption of output by strike or lock-out, as producers claim to be unable to meet labour costs.

Supplies of Chilean sulphur appear to be fully committed. Rising domestic needs and export shipments under existing commodity transactions account for current output, which, with the onset of the Chilean winter, is seasonally receding.

In Japan the industry is making efforts to

raise output in order to meet the heavy domestic demands. Tenders for imports of 16,000 tons bright sulphur have been called for submission by early July, and, failing an adequate expansion of domestic output, it is expected that towards the end of the year further outside supplies may be sought.

The approval, after a stormy passage through the Canadian House of Commons, of the Trans-Canada Pipe Line Bill, has removed the last obstacle to the start of construction work. By next year substantial sulphur supplies may be forthcoming from Alberta and also from British Columbia, where Jefferson Lake Sulphur Company has entered the field in co-operation with Pacific Petroleum Company on their Peace River Gas project.

Pyrites

No significant changes are reported in European pyrites demand for delivery in the second half-year. The trend of lower requirements in U.K. and Belgium is continuing while Germany maintains her position as the strongest buyer. Among the producing countries, domestic demand in Spain and Portugal is rising rapidly, while in Sweden many pulp manfacturers are converting plant from pyrites to brimstone use. In view of the general expansion of output last year, supplies remain ample. The rapid development in Eire of St. Patrick's Copper Mines promises to add a new and sizeable source of pyrites supply.

Summary

Under the pressure of mounting stocks in Mexico, the world sulphur market remains weak, but this is not likely to lead to further price reductions now that U.S. producers have aligned domestic and export prices. Stiff competition in world markets is paralleled to a lesser extent by the strenuous efforts of Mexican producers to increase their foothold in the U.S.A.

World sulphur requirements are at present rising more rapidly than was anticipated, and brimstone usage in particular is expanding, partly on account of new world-wide acid plant construction, but also in response to the growing tendency of users of pyrites to convert to brimstone use or to add sulphur burners to their installations.

At the same time, production capacity has at least for the time being outstripped the market, and at the current level of output the competitive position in world supply is being maintained.

UNITED STATES SULPHUR

Native Sulphur

Production of Frasch sulphur during the first quarter of 1956 which amounted to 1,493,606 tons was 10% lower than the record production achieved during the preceding quarter, but 12½% greater than in the corresponding period of 1955. Although the seasonal decline in production appears to be substantially greater than in previous years it should be remembered that it is accentuated by the peak level attained in the preceding quarter, and that output corresponds to an annual rate 4% in excess of the 1955 rate.

Apparent sales declined fractionally (¼%) compared with the previous quarter to 1,470,236 tons, but exceeded those of the corresponding quarter of last year by 3½%. Contrary to the trend for the years 1951-1955, apparent sales in March failed to show the customary strong increase. Imports of Mexican sulphur, which during the first quarter are estimated to have totalled about 50,000 tons, may partly account for this although the appearance of some weaker spots in the U.S. economy, such as the uncertainty in agricultural policy and the decline in automobile production inevitably exerted their influence.

Production of sulphuric acid totalled over 4.2 million short tons—7¼% more than during the corresponding quarter last year—as the result of continued high demand from the steel, chemical, petroleum, and detergent industries. The demand from the automobile industry remained high during January and February, but declined considerably at the end of March. Due to the uncertain agricultural situation while Congress discuss measures affecting farming legislation, and to the late spring planting season, demand for fertilizers has not been as strong as usual for the time of year.

Non-acid sulphur consumption remained high. The principal consumers were the pulp

and paper industry—whose production exceeded rated capacity—manufacturers of rayon and rubber, although usage by both rayon and rubber were affected in March when automobile output started falling off.

Exports of sulphur totalled 346,736 tons compared with 339,276 during the 1st quarter of 1955.

Stocks of Frasch sulphur at 3,204,568 tons did not substantially change throughout the quarter, having increased by only 23,400 tons (¾%). Compared with stocks at the end of March 1955 there was an increase of 113,671 tons.

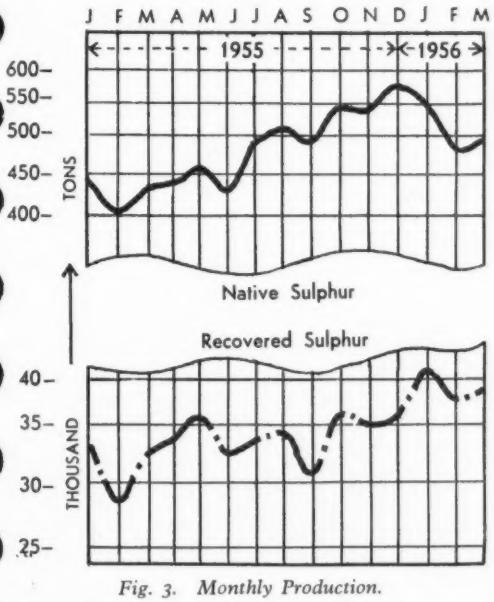


Fig. 3. Monthly Production.

Recovered Sulphur

Production of recovered sulphur during the first quarter was 116,100 tons, the highest quarterly total on record, and 8¾% greater than the total produced in the previous quarter.

Production during January of 40,900 tons, was the highest monthly output on record. Recovery facilities at natural gas plants and oil refineries, recently completed and those due to come on stream during the year, promise to raise 1956 recovered sulphur production well over the ½ million ton mark.

Apparent sales totalled 117,454 tons,* a rise of 14% compared with the previous quarter and nearly 50% higher than the first quarter 1955. As in most instances outlets for recovered sulphur are situated near recovery plants, this source of supply is assuming greater importance as the sales wholly taken up by the domestic market now account for almost 10% of total elemental sulphur usage. Stocks of recovered sulphur at the end of March totalled 118,913.*

Summary

(a) Production of native and recovered sulphur of 1,609,706 tons was 3% lower than in the preceding quarter, but exceeded that during the corresponding period of last year by over 17%. These figures reflect the increased production from nearly all domes.

(b) Apparent sales of native and recovered sulphur totalled 1,586,336 tons representing the second highest quarterly total tonnage on record.

(c) In view of the continued high level of industrial activity particularly in January and February, U.S. domestic consumption of elemental sulphur is estimated to have amounted to over 1¼ million tons, about 10% more than in the first quarter 1955.

(d) Stocks of native and recovered sulphur at the end of March totalled 3,323,481 tons, an increase of 108,575 tons compared with the corresponding quarter last year.

(e) The trend of Frasch output during the coming months is uncertain, in that its level, inevitably lower than at present, will be influenced by factors both in the domestic and export markets.

The anticipated decline in industrial activity during the second and third quarters of this year, coupled with seasonal decrease of sulphur use during the summer months, may be accentuated by the rising imports from Mexico and the expanding level of recovered sulphur sales. At the same time, U.S. producers are meeting increasing competition in the overseas markets from other suppliers.

*Subject to confirmation by U.S. Bureau of Mines.

New Sulphur Recovery Plants at U.S. Oil Refineries

THE expansion in recent years of facilities for the extraction and recovery of sulphur from sour natural gas and from oil refinery gases in the U.S.A. has been so continuous and widespread that anouncements of new plants tend almost to be regarded as commonplace. This applies in particular to installations at oil refineries which in general are relatively small, rarely exceeding an annual output capacity of 20,000 tons sulphur. Yet the combined output of the 40 or so recovery plants in operation to-day meet over 10% of U.S.A. domestic consumption. The expansion of this branch of the sulphur industry is determined largely by the increased use of the refinery feed stock of sour crudes of U.S. as well as Middle East origin, which giving rise to hydrogen sulphide in the process necessitate sulphur removal primarily to prevent air pollution.

The latest developments concern the Sun Oil Company whose recovery plant at the Marcus Hook refinery having started operating in October 1955, has reached full capacity in recent weeks, and the Union Oil Company of California who started up their second recovery plant at the Santa Maria oil refinery at the end of April.

UNION OIL COMPANY OF CALIFORNIA

Both the original Santa Maria refinery sulphur plant, which was completed in April, 1955, and the new sulphur plant, were designed by the Girdler Corporation of Louisville, Kentucky, and erected by the Bechtel Corporation of San Francisco, California. The two plants are substantially identical as to general layout and capacity. Each plant has a rated capacity of 42 long tons per day of sulphur and is designed to convert 95% of the available sulphur in the feed gas stream into liquid elemental sulphur. The sulphur product is specified to be 99.5% pure with a maximum ash content of 0.25% by weight.

The plants employ the modified Klaus process. The H_2S is converted to sulphur by controlled combustion with air in which one-third of the hydrogen sulphide is burned to form sulphur dioxide which reacts with the remaining two-thirds of the hydrogen sulphide to form sulphur and water vapour. The sulphur vapour is condensed and recovered as liquid sulphur. In the process, H_2S gas passes first through a knock-out drum which removes entrained liquid. The gas is then burnt in a reaction furnace where the air is controlled to burn only one-third of the hydrogen sulphide to sulphur dioxide. Some sulphur is formed as a vapour in the reaction furnace with approximately one-half of this amount condensing and draining to the sulphur storage pit. Heat from the furnace is used to generate 180 p.s.i.g. steam for use in the plant.

The gases leaving the reaction furnace pass to the first-stage catalytic converter. This vessel contains a bed of activated bauxite catalyst which promotes further reaction of the hydrogen sulphide and sulphur dioxide. The reaction is exothermic, causing the temperature of the gases to rise across the bed. Gases from the bottom of the converter enter the first stage sulphur condenser where they are cooled and the sulphur is condensed and drained to the sulphur storage pit. Low pressure steam (40 p.s.i.g.) is produced on the shell side of this condenser and is used for heating requirements in the plant. The gases are then reheated and passed to the second-stage converter. The gases from the bottom of the second-stage converter pass to an accumulator where they are cooled and the sulphur vapour is condensed. The liquid sulphur is drained to the sulphur storage pit. The gases from the top of the accumulator go to an incinerator where all residual sulphur compounds are converted to sulphur dioxide before the effluent gases are discharged to the atmosphere.

General operation of the first Santa Maria sulphur plant has been very good, and the plant proved its ability to meet its designed production capacity and designed conversion of hydrogen sulphide to elemental sulphur. The sulphur produced is placed on the market through the company's subsidiary, the Brea Chemical Company, for distribution to chemical and agricultural users.

SUN OIL COMPANY

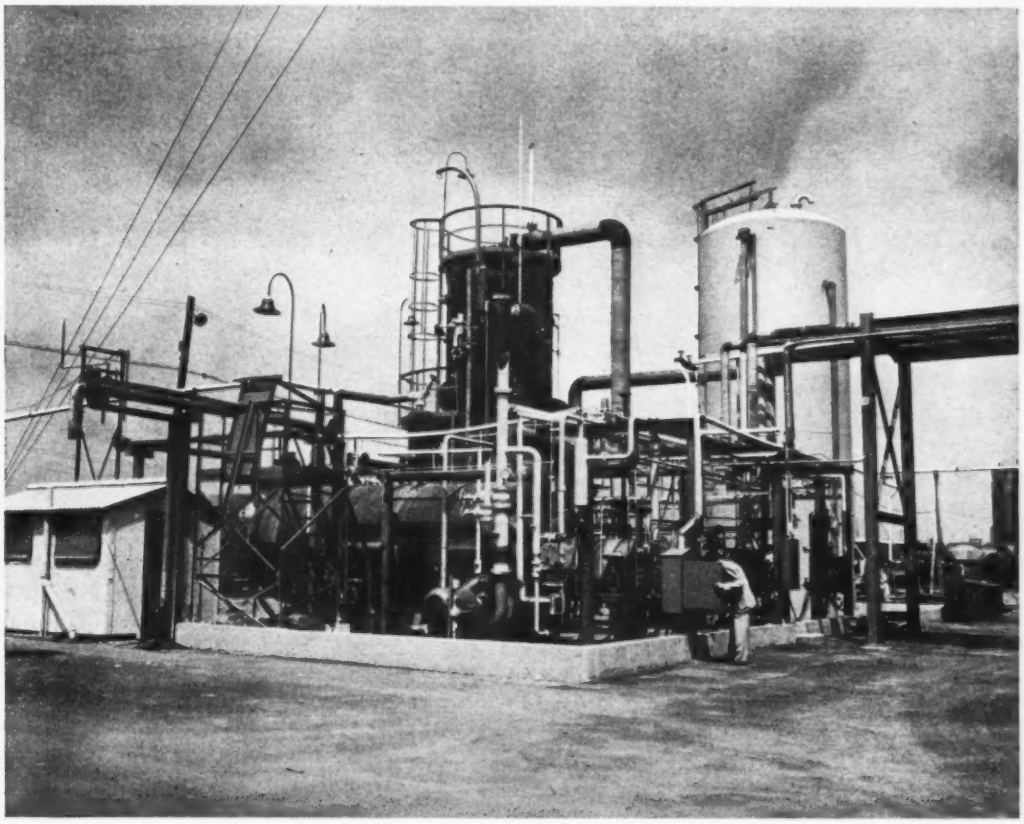
Installed at the company's oil refinery at Marcus Hook, Pa., the sulphur extraction and

recovery plant embodies a similar process to that outlined above. The charge stream to the sulphur unit is hydrogen sulphide recovered from light hydrocarbon gases from a catalytic cracking unit. This hydrogen sulphide stream is heated in a boiler with a special combustion chamber. At this point, about one-third of the hydrogen sulphide is converted to sulphur dioxide. The sulphur dioxide is reacted catalytically with hydrogen sulphide to form free sulphur and water vapours. The stream is then cooled and free molten sulphur drained off. Remaining gases are reheated in an auxiliary burner and routed through a second catalytic convertor and cooler. In the final step, a coalescer removes any suspended sulphur. Residual gases containing a small amount of hydrogen sulphide and sulphur dioxide are completely burned in an incinerator.

This unit was installed primarily to prevent the possibility of air pollution as this refinery uses high-sulphur crude oil.

Built by the Ralph M. Parsons Company of New York, the plant which has a rated daily capacity of 30 tons sulphur, went on stream in October 1955, at an initial production rate of 14 t.p.d., and is now operating at full capacity, following the arising of additional quantities of H_2S in the gas stream. It achieves approximately 93% conversion of hydrogen sulphide to molten sulphur.

The combined output of the two new projects will add 24,000 tons annually to U.S. sulphur supplies.



Sulphur Recovery Plant at Marcus Hook.

We are indebted to Union Oil Company of California and Sun Oil Company for information and the photograph which they kindly placed at our disposal.

UNITED KINGDOM SULPHUR

Consumption

DURING the first quarter of 1956 consumption of sulphur in all forms* amounting to 242,000 tons, was 4¾% greater than in the preceding quarter and 8½% greater than in the corresponding period in 1955. It is estimated that of the total consumption about 38¾% was met from indigenous resources (sulphur in anhydrite used for acid manufacture, spent oxide, zinc smelter gases and recovered from coke oven and oil refinery gases), 22¾% from imported pyrites and 38½% from imported brimstone. Actual imports during the first quarter amounted to 90,547 tons brimstone (valued at £15 7s. per ton) and 113,096 tons pyrites (valued at £7 16s. per ton).

Elemental sulphur use, both "regular" and "acid,' although slightly lower (1¼% and 1½% respectively) than during the preceding quarter, shows a moderate (5% and 3½%) increase over the corresponding period in 1955. Consumption during the first quarter was at an annual rate of 420,000 tons, of which acid sulphur represents 300,000 tons. Details of consumption are as follows :—

	1st Qtr. 1956	*4th Qtr. 1955*	*Change § %*	*1st Qtr. 1955*	*Change § %*
Elemental Sulphur :					
Acid : Imported	69,100	70,400	− 1¾	65,000	+ 6
Recovered, H_2S and Filter cake ...	6,000	5,800	+ 3½	7,500	−20
Total "Acid" sulphur	75,100	76,200	− 1½	72,500	+ 3½
Regular	29,800	30,200	− 1¼	28,500	+ 5
Total Elemental Sulphur	104,900	106,400	− 1½	101,000	+ 4
Pyrites	115,300	108,700	+ 5¾	124,600	− 7½
Spent Oxide	63,400	65,400	− 3	69,700	− 9
Anhydrite	176,700	134,000	+32	66,100	+167
Zinc Concentrates	47,600	45,000	+ 3	48,900	− 2¾

§Percentage figures shown indicate change between earlier periods and the first quarter 1956.

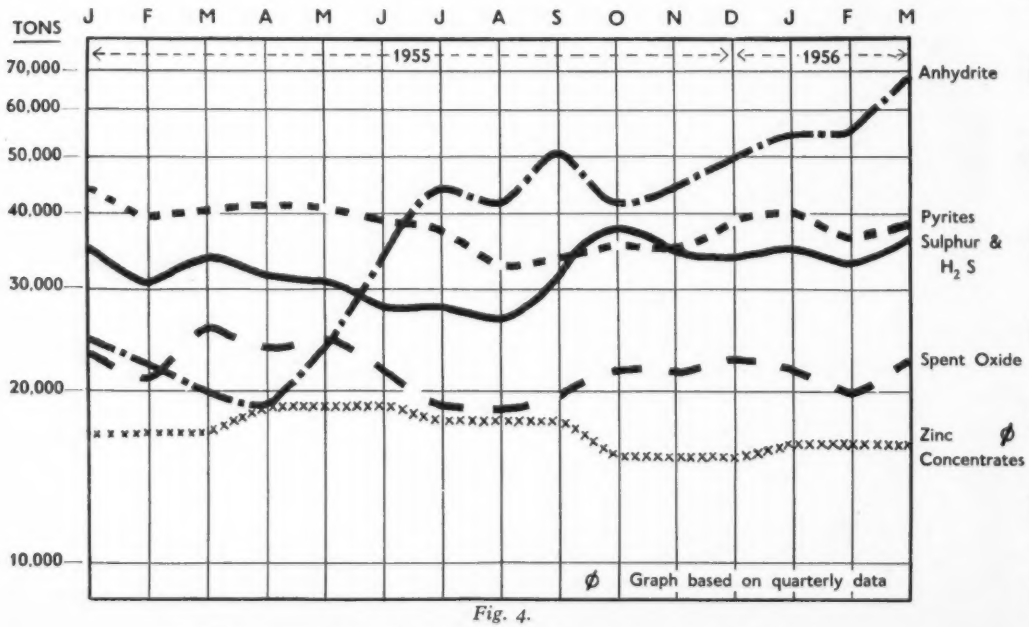


Fig. 4.

*Excluding consumption of sulphur in anhydrite for direct manufacture of sulphate of ammonia.

The main feature in the greater overall consumption of sulphur is the increased use of anhydrite in the manufacture of sulphuric acid. This has affected mainly the consumption of pyrites and spent oxide, which compared with the corresponding period of 1955 declined 7½% and 9% respectively, in spite of the increase in total sulphur use. Compared with the preceding quarter pyrites consumption increased 5¾%, mainly on account of the start of operations of the new turbulent layer roasting plant of British Titan Products Co. Ltd. at Grimsby.

Sulphuric Acid†

Production during the first quarter 1956 amounted to 593,500 tons (100% H_2SO_4), the highest quarterly total on record. Output representing an annual rate of 2.37 million tons was 8¼% greater than the preceding quarter and 10½% greater than during the corresponding period last year.

Acid production resulted from the use of sulphurous raw materials in the following proportions :—

	1st Qtr. 1956	*4th Qtr. 1955*	*1st Qtr. 1955*
	%	%	%
Elemental Sulphur :			
Imported brimstone ...	32½	35	33½
Recovered, H_2S and Filter cake ...	3	3	4
Sulphur in :			
Pyrites	25¾	25¾	30½
Spent Oxide	14½	15½	17¼
Anhydrite	17½	14	7½
Zinc Concentrate ...	6¾	6¾	7½
Total Sulphur (000 tons)	212	201	194

During the first quarter 1956 effective production capacity rose to an annual rate of 2.75 million tons of which 86.3% was employed. New capacity amounted to 17,800 tons, an increase of 2¾% over the previous quarter, and was mainly attributable to the increased scale of operations of Solway Chemicals Ltd., and to the start of operations of the pyrites acid plant of British Titan Products Co. Ltd. It is estimated that brimstone acid plants operated at about 85% of capacity, pyrites roasters at about 75% and spent oxide burners at about 80%.

Acid Consumption

Consumption of sulphuric acid amounted to 593,885 tons (100% H_2SO_4), representing an increase of 6¼% over the preceding quarter and 8% over that of the first quarter for 1955.

Acid usage by the main consumer groups in the respective periods was as follows :—

	1st Qtr. 1956		*1st Qtr. 1955*	
	000 tons	%	*000 tons*	%
Fertilizers	226	38.0	211	38.3
Chemicals	75	12.6	70	12.7
Titanium Dioxide and Lithopone ...	66	11.1	59	10.8
Rayon & Transparent Paper	74	12.5	68	12.4
Metallurgy	34	5.7	33	6.0
Oil Refining	16	2.7	14	2.5
Dyes	20	3.4	21	3.8
Soaps & Detergents ...	18	3.0	14	2.6
Miscellaneous ...	65	10.9	60	10.9
Total	594	100	550	100

The principal changes in individual consuming industries compared with the corresponding period in 1955 were as follows:—

	Change	
	tons	%
Titanium Dioxide	+10,800	+19½
Superphosphate	+10,600	+ 7¾
Rayon & Transparent Paper ...	+ 6,000	+ 8¾
Soap, Glylcerine & Detergents	+ 4,700	+34
Sulphate of Ammonia	+ 4,700	+ 6½

Quantitively smaller, but nevertheless important changes occurred in acid used for bromine (+34½%), drugs and fine chemicals (−36½%), plastics (+28½%), explosives (−27½%), oil refining and petroleum production (+21½%), sulphates of copper, nickel, etc. (+41%).

Raw Material Stocks

During the first quarter of 1956 stocks remained virtually unchanged. On 31st March stocks of acid and regular sulphur totalled 85,300 tons, an increase of 100 tons and representing about eleven weeks' supply. Pyrites stocks, having also risen 100 tons, amounted to 203,400 tons, representing 23 weeks' usage, and spent oxide stocks at 124,100 tons were 900 tons lower, representing 25 weeks' supply.

Summary

The significant features of developments in the sulphur industry during the first quarter are :—

(a) The peak level of consumption of sulphur in various forms occasioned partly by the sustained demand by non-acid users, but primarily by the strong activity of acid industry whose output represents an annual rate of 2.37 million tons (100% H_2SO_4).

(b) As the result of all new anhydrite acid projects, which started in 1955, attaining their designed level of output, consumption

†We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

of sulphur in anhydrite accounted for 17½% of the total consumed in the manufacture of acid. Indeed the tonnage of anhydrite consumed in the first quarter almost exactly equalled the entire annual use in 1954.

The entire arisings of new anhydrite acid from United Sulphuric Acid Corporation Ltd., Widnes, and Solway Chemicals Ltd., Whitehaven, are reported to be moving satisfactorily: the former have an assured outlet to the 11 sponsors of the project, whereas the latter, having expanded their own requirements for the manufacture of wet phosphoric acid, are reported to have sold the entire surplus to users within about 100 miles of Whitehaven, mainly in the North-East and the Midlands.

In view of the high level of activity throughout the acid industry, the impact of greater anhydrite acid supplies did not materially affect the use of other raw materials. Significantly, comparing the present pattern of raw materials usage with the first quarter 1955, elemental sulphur use has increased quantitively and its share of total usage has only slightly declined. Spent oxide and especially pyrites have so far shown the heaviest reduction and it is expected that during the summer months, when overall acid production is lower, this trend will be accentuated.

The Removal of Oxides of Sulphur from Flue Gases and Sulphur Recovery

Introduction

Many methods for the removal of oxides of sulphur from flue gases have been proposed, but only two processes up to the present time have passed through the pilot-plant stage to full-scale operation. One of these processes is the Battersea process which is in operation at the coal-fired generating station at Battersea and at the oil-fired generating station at Bankside. The other process, known as the Howden-I.C.I. process, was used at the Fulham generating station before the war. Both these processes use chalk or lime as the alkaline reagent. The Battersea process is an effluent process in which the flue gases are washed with a large volume of river water to which a little chalk is added. The final product, calcium sulphate, is discharged in solution into the river. The Howden-I.C.I. process was a non-effluent process in which the gases were scrubbed with a circulating suspension of lime or chalk in water and the calcium sulphate was separated in the plant as a sludge. No technically and economically satisfactory method of recovering the sulphur in a useful form from the sludge could be devised.

Both the Battersea and Howden-I.C.I. processes are expensive, and at present prices, the total cost of washing would amount to eight to ten shillings per ton of coal burned for a new Battersea plant and at least twelve shillings per ton of coal burned for a new Howden-I.C.I. plant. The use of an ammonia solution has advantages over the use of chalk, although the latter is the cheapest of the possible alkaline reagents. The rate of absorption of sulphur dioxide by an ammonia solution is high, ammonium salts are very soluble, and a saleable product is produced.

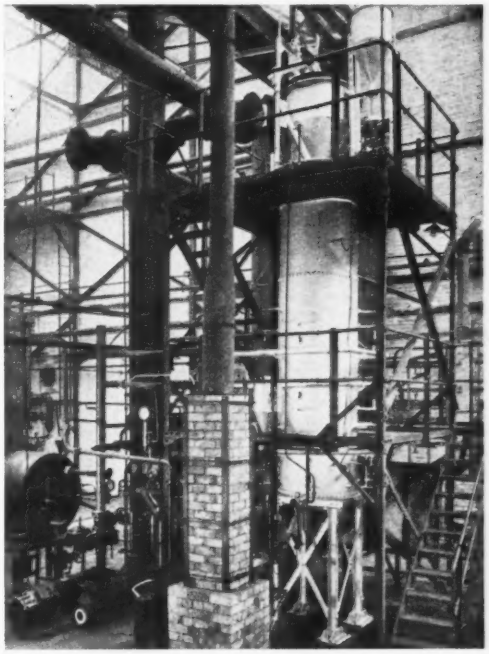
The Fulham-Simon-Carves Ammonia Process

The process consists in scrubbing the flue gases with a concentrated solution of ammonium salts to which ammonia is added at a rate sufficient to combine with the oxides of sulphur. The concentration of the solution is kept constant by running off liquor from the scrubber when necessary and replacing it with water. When sulphur dioxide is absorbed by a solution of pure ammonia, ammonium sulphite and bisulphite are formed. Under the conditions prevailing in the scrubber some of the ammonium sulphite becomes oxidised to amonium sulphate. Conversion to ammonium sulphate can be completed by aeration, in a separate vessel, of the liquor withdrawn from the scrubber. If crude ammonia (concentrated gas-works ammonia liquor), which contains about 1-2% of hydrogen sulphide, is used as the source of ammonia, ammonium thiosulphate is formed in addition to the salts mentioned. Ammonium

sulphate and sulphur are produced by heating the scrubber liquor with the addition of the calculated (small) amount of sulphuric acid in an autoclave to a temperature of about 180°C and under a pressure of about 200 lb/sq.in. With crude gas liquor as the source of ammonia, about 90% of the product is ammonium sulphate suitable for use as a fertilizer and about 10% is sulphur.

Pilot-plant experiments were started at the Fulham generating station in 1939. These experiments showed that the scrubbing process was efficient and that the loss of ammonia could be reduced to a small amount provided that satisfactory control of the addition of ammonia to the scrubber, and therefore of the composition of the scrubbing liquor, was maintained. At first the control of the addition of ammonia was carried out from recordings of the pH value of the scrubber liquor, but this method was not very satisfactory when the liquor became concentrated. In later experiments, the composition of the washed gases was used as a guide. These experiments came to an end in 1940 owing to the war. Subsequently, an alternative method of controlling the addition of ammonia, based on the recording of the excess partial pressure of either sulphur dioxide or ammonia in a gas which had been in contact with the scrubber liquor, was devised at the Fulham generating station, and this method appeared to be suitable for controlling an ammonia scrubbing process.

After the war, it was decided that a further investigation of the process using the new method of control should be carried out. These experiments have been in progress since 1948 at the Fuel Research Station of the Department of Scientific and Industrial Research in collaboration with Simon-Carves Ltd., and the Central Electricity Authority. The pilot-plant at the Fuel Research Station treats 25,000 cu. ft. of flue gas per hour. Efficiencies of removal of oxides of sulphur of over 95%, with very little loss of ammonia in the washed gases, have been obtained. The advantage of the process is that saleable products are obtained. It would be cheaper to operate on a full scale than the lime processes in which no saleable product is obtained. A much larger pilot plant to obtain design and cost data for a full-sized installation is now being installed by the Central Electricity Authority at the Nottingham generating station. This plant is designed to treat 2 million cu. ft. of flue gases per hour.



Pilot Plant at the Fuel Research Station.

Preliminary estimates of the cost of the process were made by Craxford, Poll and Walker.* The case considered was that of a generating station burning 1 million tons of coal a year, the coal to contain 1.2% sulphur. It was assumed that 90% of the sulphur would be present in the flue gases and that 95% of the sulphur compounds in the gases would be recovered in the ammonia scrubbing plant. Under these conditions the plant would produce 33,700 tons of ammonium sulphate and 2,600 tons of sulphur a year, taking into account the sulphur compounds in the crude gas liquor and the sulphuric acid used in the autoclaving stage of the process.

Other assumptions made were :

(a) that concentrated gas liquor could be obtained at a price within the limits 3s. 8d. and 7s. per unit (0.01 ton NH_3),

(b) that the design of the scrubbers would be

*Journal of the Institute of Fuel, 1953, **25**, 357

based either on those of the Battersea process or the Howden-I.C.I. process,

(c) that ammonium sulphate was worth £17 per ton and sulphur £17 10s. per ton.

On these assumptions, it was estimated that the process would be profitable using either type of scrubber if ammonia could be obtained at a price near the lower limit. If ammonia cost 7s. a unit, the process would cost about 1s. per ton of coal burned, and

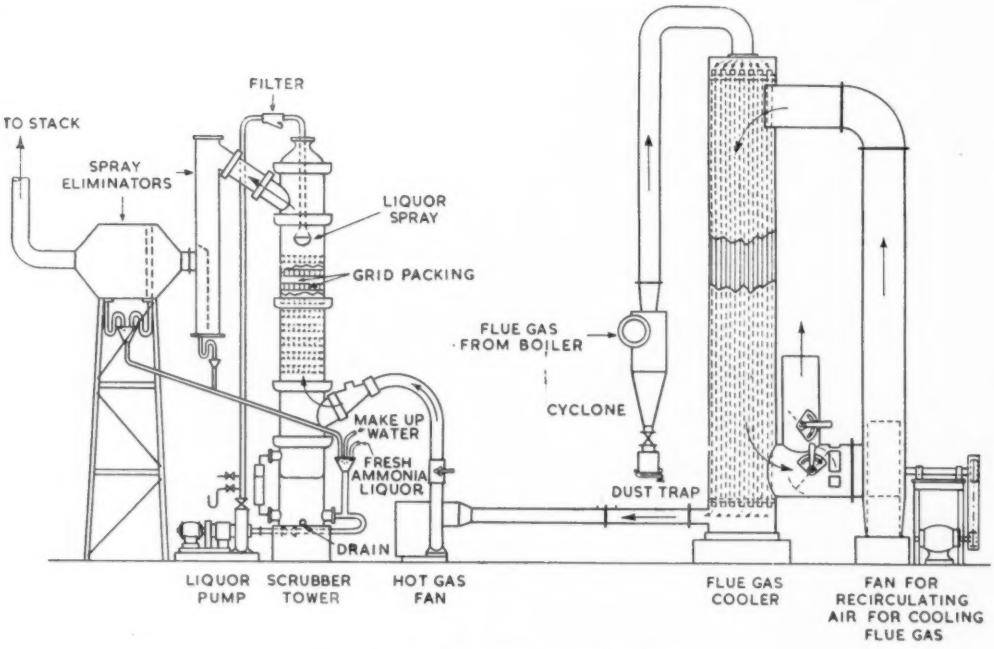


Fig. 5. Flow diagram of the pilot plant.

2s. 6d. per ton of coal burned, depending on whether scrubbers of the Battersea type or of the Howden-I.C.I. type were used.

The Fulham - Simon - Carves ammonia process is the most promising process for the removal of oxides of sulphur from flue gases and the recovery of the sulphur in a useful form that has yet been devised. It has one drawback, however, in that there is a limit to the amount of crude concentrated ammonia liquor available from gas works and coke oven plants. There is sufficient of this ammonia to remove only 0.1 million tons of the 0.5 million tons of sulphur emitted as sulphur dioxide by generating stations, or in other words, to treat the flue gases from 8 stations each burning 1 million tons of coal a year, without taking into account other large fuel-burning installations. The ammonium sulphate market would not be upset, since ammonium sulphate is already made from gas liquor by neutralising with sulphuric acid. This acid would be saved for other purposes by using the ammonia for gas washing. Further application of the process, using synthetic ammonia, would have a marked effect on the economics of the process, which would be less favourable, and would cause repercussions on the sulphate market.

For these reasons, the possibility of devising other methods whereby sulphuric acid or sulphur could be obtained as the end product is being considered at the Fuel Research Station.

We are indebted to the Director of the Fuel Research Station of the Department of Scientific and Industrial Research for the account placed at our disposal and permission to publish the diagram and photograph which are Crown copyright.

Sulphur Consumption in Australia

General

THE continued expansion of fertiliser demand in Australia in 1955 has been fully reflected by the sulphuric acid industry whose level of activities rose to a new peak and resulted in a corresponding rise of sulphur consumption. The industry continued to rely for its raw material supply primarily on imported elemental sulphur. Its dominant use was slightly accentuated, despite the start of operations in July 1955 of the plant of *Sulphuric Acid Limited* at Birkenhead which, based on Nairne Pyrites concentrate, is one of the major projects initiated in 1951/2 with a view to making greater use of indigenous sulphur resources.

Consumption 1955

Sulphur consumption in all forms amounted to about 327,000 tons, an increase of about 19% compared with 1954. The use of about 10,500 tons elemental sulphur for non-acid purposes accounted for only 5.3% of total brimstone usage, but in view of a general expansion in most "regular" sulphur uses, consumption was over 11% greater than in 1954. Rubber compounding took up about 2,200 tons sulphur, chemicals 4,600 tons and agricultural and other uses 3,700 tons.

Details of raw materials used in the manufacture of sulphuric acid are as follows :—

	1955 tons	*1954* tons	*Change* %
Brimstone	195,045	159,247	+22½
Pyrites	174,728	153,500*	+14
Zinc Concentrates ...	114,341	125,900*	− 9¼
Spent Oxide ...	13,779	13,400*	+ 3
Total Sulphur ...	316,500	274,800	+15¼

*Approximate.

The consumption of sulphur for acid manufacture increased by nearly 42,000 tons. The bulk of the increase—36,000 tons—was in the form of imported elemental sulphur, reflecting its preferential use, notwithstanding the Government provisions for subsidy payments to acid makers using indigenous raw materials. Pyrites consumption increased by about 10,000 tons sulphur primarily on account of the start of operations in July 1955 at the plant of Sulphuric Acid Ltd. The recession of about 9% in the use of sulphur contained in zinc smelter gases is mainly attributable to the cessation of operations at the Wallaroo and Birkenhead plants of *Wallaroo-Mount Lyell Fertilizers Ltd.* whose acid requirements were being met by supplies from the new pyrites acid plant of Sulphuric Acid Ltd.

Sulphuric Acid

Production of sulphuric acid in 1955 totalled 895,785 tons (100% H_2SO_4), an increase of about 118,000 tons (15¼%) compared with 1954. The proportion of acid produced from the various raw materials was as follows :—

	1955 %	*1954* %
Acid produced from :		
Brimstone	63.9	60.6
Pyrites	24.3	24.6
Zinc Smelter Gases ...	10.4	13.2
Spent Oxide	1.4	1.6
Total Sulphuric Acid 000 tons (100% H_2SO_4)	896	778

Consumption of sulphuric acid in 1955, stimulated primarily by the expanding requirements for fertilizer manufacture, notably superphosphates, increased by about 100,000 tons (13%) to 878,256 tons (100% H_2SO_4).

The distribution of acid use by the main consumer group was as follows :—

	1954 000 tons	%	*1955* 000 tons	%
Superphosphate ...	636.1	81.7	723.0	82.3
Ammonium Sulphate	57.5	7.4	68.3	7.8
Metallurgy	27.2	3.5	87.0	9.9
Chemicals	22.6	2.9		
Other	34.5	4.5		
Total	777.9	100	878.3	100

Imports

To meet the industry's elemental sulphur requirements total imports increased by about 18,000 tons to 205,545 tons in 1955. U.S.A. maintained its position as the largest supplier accounting for 80% of total imports (84% in 1954). Imports from Mexico, accounting for 12½% of the total, entered Australian consumption for the first time. The balance of imports originated from Japan but Norwegian sulphur, which accounted for about 5% of imports in 1954, did not contribute to Australia's sulphur supplies.

Outlook for 1956

During the current year overall consumption of sulphur in all forms is expected to increase by at least 10% as indications to date

point to the continuation of the rising trend of fertilizer demand at a cumulative annual rate of about 13%. The only additional capacity available to meet the greater demand for sulphuric acid is represented by the pyrites-based plant of Sulphuric Acid Ltd., (100,000 tons per annum 100% H_2SO_4) at Birkenhead and the by-product acid plant based on zinc smelter gases of Electrolytic Zinc Co. of Australia at Risdon (60,000 tons per annum). The former, operating for the first full year, should supply about 60,000 tons acid in excess of last year's supplies, while the latter given adequate power supply for the manufacture of synthetic ammonia is expected to be worked more fully to supply the needs for ammonium sulphate manufacture; thus it may contribute 10,000 to 15,000 tons more than in 1955. The balance of requirements totalling perhaps up to 30,000 tons would have to result from more intensive operation of established acid making facilities. The other major projects which were completed at the turn of the year influence Australia's balance of use of sulphurous raw materials without, however, adding to acid supplies. They are the by-product acid plant based on lead sinter gases of *Broken Hill Associated Smelters Pty. Ltd.* which started in January and supplants about 16,000 tons per annum brimstone and the new turbulent layer roaster of *Sulphide Corporation Ltd.* at Cockle Creek. The latter plant, as reported in the Annual Report by Mr. Govett, the Chairman of *Consolidated Zinc Corporation*, was completed late last year, but will not come into operation until a series of modifications has been effected. When in full operation it will consume Mount Morgan pyrites at an annual rate of about 26,000 tons in place of about 12,000 tons brimstone.

In the light of these developments it is expected that during the current year acid produced from indigenous raw materials may account for as much as 45% of a total output of close on one million tons. Although the possible reduction of brimstone acid output to 55% of the total—compared witht 63½% in 1955—may result in a slight decrease in acid sulphur usage, it is probable, in view of the uncertainty of the rate of operations at some of the new plants, that the level of sulphur imports will be maintained if not slightly increased.

This modification of last year's trend of raw materials consumption when, in spite of the sulphur bounty paid to users of indigenous raw materials, the ready availability and the lowered price of brimstone had tended to counteract the Government's aim to achieve 65% self sufficiency, would seem to come at an opportune time. During the first three quarters of 1955 bounty payments amounted to about £A2 10s. per ton acid, but owing to a rise of nearly £A3 in landed duty free cost of imported brimstone, which controls the level of bounty payments, these decreased to £A1 10s. in the fourth quarter. As the increased cost of brimstone is wholly due to higher freights which do not so far show signs of reverting to lower levels, it is probable that this year the bounty may even drop below this level with the result that the Government would not be embarrassed by having to reduce it arbitrarily which would be the case in the event of the increased use of indigenous raw materials qualifying for a total bounty payment in excess of £A600,000.

Future Outlook

Whereas the present trend of raw materials usage accords with the Government's plans, the pressure of acid demand presents industry and Government with a new situation. Following the closure in 1954 and 1955 of three by-product sulphuric acid plants (Wallaroo, Birkenhead and Port Pirie) which were replaced by new and larger pyrites acid plant of Sulphuric Acid Limited, Australia's rated sulphuric acid capacity at the start of 1956 is estimated at 1,030,000 tons (100% H_2SO_4). With rising demand necessitating an output in 1956 approaching the million-ton mark the existing facilities are not thought adequate to sustain output at this level for any considerable period of time and new construction, to provide a margin of at least 10% but preferably 20% between capacity and desired output, appears to be a matter of urgency.

The prospect of authorising the new construction of acid plants with an aggregate annual capacity of up to 200,000 tons does however present the Federal Government with a series of difficult problems. Its established policy, apart from any questions of dependence on foreign sources of supply, frowns upon the possibility of having to agree to U.S. dollar expenditure, which, in the case of the expan-

sion taking the form of brimstone acid plants, would at present day sulphur prices amount to over $1½ million (£A670,000) annually, excluding ocean freight of which undoubtedly a part would also have to be paid in dollars. On the other hand if such a volume of acid were to be produced from indigenous raw materials, the Government's liability under the sulphur bounty scheme, even at the latest reduced level of payments, would increase by £A300,000 annually, half as much again as the present statutory limit which has practically been reached already. Such an addition to inflationary pressure would not be desirable in the prevailing economic climate in Australia. Another factor, which assumes importance in the light of the shortage of investment capital, is the relative cost of plant, with brimstone acid capacity of this magnitude at £A2½ million clearly placing a lesser strain on resources than pyrites acid capacity costing £A5½ million. Subject to capital costs the Government will undoubtedly give primary consideration to projects based on the use of recovered sulphur notably from oil refinery gases, gas-from-oil plants, possibly the Morwell brown coal gasification project, and of course from non-ferrous smelter gases. The scope of these sources of sulphur supply is however circumscribed as to location and, for the time being at least, they can only play a supplementary role. The main issue rests between the use of imported brimstone and indigenous pyrites, and from the point of view of industrial economics there is little doubt that acid makers favour brimstone. On balance, under the prevailing conditions, the Government is thought likely to align its views with those of private industry.

Sulphur in Mexico

Changes in Ownership

THE sale at the end of April by the Brady Brothers—Lawrence, William and Ashton—of the remaining major assets of their wholly owned Pan American Exploration Company de Mexico, represented by the controlling interest in Gulf Sulphur Corporation and an important holding in Mexican Gulf Sulphur Company, marks the end of an era which brought Mexico from obscurity to a challenging position in the world sulphur industry. This pioneering period started in the early forties when the Brady Brothers succeeded in locating the sulphur domes on the Isthmus of Tehuantepec, three of which they explored and developed. In 1947 they sold the Jaltipan concession to a group of Texas oil men, who formed the Pan American Sulphur Company which now, under the presidency of Mr. Harry C. Webb, is the largest producer. The minority share holding, believed to have amounted to 10% of the authorised capital stock, which the Brady Brothers then retained was sold by them early this year to a banking syndicate.

In 1952 the San Cristobal concession was bought by a U.S. group headed by Mr. Paul Nachtman, who formed the Mexican Gulf Sulphur Company. In this company, which became the first producer of Frasch sulphur outside the U.S.A., the Brady Brothers also retained a minority interest amounting to 15% of the issued voting common stocks. The last of their three domes, Las Salinas, the Brady Brothers developed further through the Gulf Sulphur Corporation which brought it right up to the producing stage by the installation of a large-scale Frasch plant which was completed early this year.

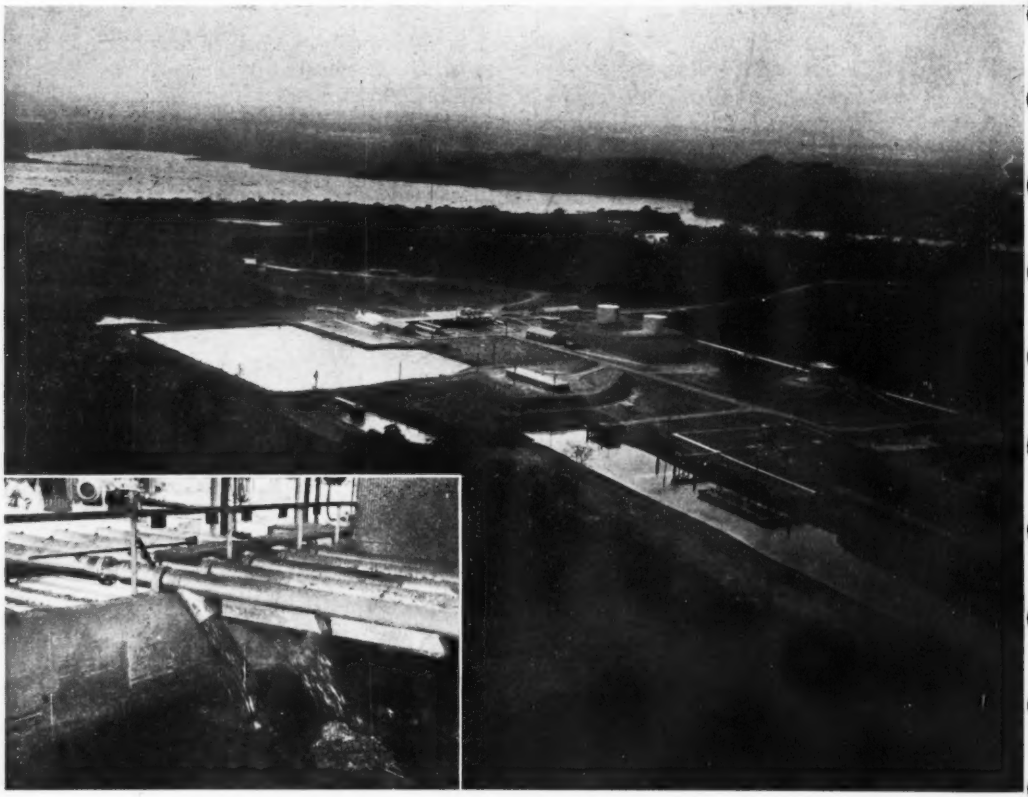
After lengthy negotiations, not by any means confined to the eventual purchasers, the Brady's controlling share holding in Gulf Sulphur Corporation has now been acquired jointly by Bear Stearns & Company, the New York investment house, and the Hudson Engineering Company of Houston. Bear Stearns had been prominent in earlier financing operations of Gulf Sulphur Corporation as recently as last July when they underwrote the issue of $4½ million of convertible debentures, while Hudson Engineering built the plant at Las Salinas on payment of a fee, a royalty and an issue of stock. At the same time Bear Stearns and Hudson Engineering Company acquired the Brady's 15% holding in Mexican Gulf Sulphur. Through their new parent companies there is now an even closer link between the two sulphur producers than existed previously on account of geographical propinquity and common interest in the movement of their sulphur output down the Coachapa River to the port of Coatzacoalcos.

The future of the 5,000 acre concession adjoining that of Gulf Sulphur Corporation — probably the Brady Brothers' last stake in the Tehuantepec sulphur through their Pan American Exploration Company de Mexico — is not yet determined. Potentially important, since one of the sulphur structures on Gulf's property, Vista Hermosa, is believed to extend into this concession, it is likely to be the subject of a further arrangement between the two companies.

GULF SULPHUR CORPORATION

Following the take-over, an early reorganisation of the company's management was carried out. Former vice-president Mr. Stuart C. Dorman was elected president, Mr. Harvey D. McLean, of Hudson Engineering, vice-president, and Mr. Joseph F. Patten, partner of Bear Stearns, secretary. The new board of directors also includes Mr. V. Theodore Low and Mr. Harrie T. Shea of Bear Stearns, Mr. Edward H. Hudson and Mr. V. V. Jacomini of Hudson Engineering, Mr. Jack T. Trotter, attorney and accountant, and Mr. Robert H. van Doren.

Steaming of the first well, which had been deferred pending the successful completion of the financial negotiations, and in anticipation of which boilers, steam lines and ancillary plant had been tested for several weeks previously and proved 25% in excess of guarantees, was started promptly, and on 3rd May sulphur was first produced. The plant, designed by Mr. James Woodburn, has several novel features, notably the use of three Babcock and Wilcox 60,000 pound boilers instead of Sterling type boilers, which are traditional in the Frasch sulphur industry. Incorporating Bailey automatic combustion control, they are integral type units with complete water wall and their installation accords



Gulf Sulphur Corporation: Las Salinas Frasch sulphur plant and installations. Inset: First production from metering section.

with modern power plant practice. The water requirements of the plant are drawn by pump from the Coachapa River into a 14 million gallons reservoir which is served by a million gallon flock basin; electricity is supplied by two 300kw. generators and compressed air by two 500 cu. ft./minute compressors.

Initial operations are confined to the part of the concession area known as Mezquital where some 50 exploratory wells were drilled in an area of about 75 acres, proving a little over one-hundredth of the whole concession. This sulphur structure was estimated by Mr. W. H. Maddox, a consulting geologist, to contain 13½ million tons sulphur.

According to Mr. Stuart C. Dorman, production by mid-May had reached a daily rate of 400 tons sulphur containing 99.3-99.5% sulphur, 0.021% ash. This rate is being maintained for several months and it is intended to raise it to 1,000 tons per day in the autumn. In the meantime work on sulphur storage and loading facilities at the port of Coatzacoalcos is being hastened. The first barge-load of liquid sulphur was shipped to temporary storage at the port on 12th May.

MEXICAN GULF SULPHUR COMPANY

Contrary to earlier hopes, the company's production difficulties remain unresolved. In the absence of adequate production the company initially met contractual engagements from existing saleable stocks. Following the closer integration of the company's interests with those of Gulf Sulphur Corporation, the latter is understood to have come to an arrangement with Mexican Gulf, who will stockpile, load and sell Salinas sulphur on a temporary basis. Although no authentic information is yet available, it is reliably reported that the production troubles were caused by difficult underground formations which the exploratory investigations failed to disclose. Inevitably this setback is affecting the company's financial position which, following favourable early production and initial satisfactory marketing results, had been promising.

PAN AMERICAN SULPHUR COMPANY

The company's annual report for 1955 presented by the Chairman of the Board, Mr. T. R. Parker, and the President, Mr. Harry C. Webb, expresses satisfaction with the year's achievements. Including the testing period* late in 1954, the output at Jaltipan up to the 31st December 1955 totalled 423,000 tons. Based on the assumption of increasing sulphur demand in Mexico and in world markets, and in order to protect customers with whom long-term contracts had been concluded, the Board authorised in August 1955 the expenditure of $1½ million to increase the daily water capacity of the plant to 5 million gallons, an increase of 50%. The construction work is being carried out by Brown & Root, Inc., of Houston, and is due to be completed in August this year. Shipments in 1955 totalled about 138,000 tons which included sales on the domestic market, to the United Kingdom, Europe, U.S.A., South America, South Africa, and Australia. Sales commitments for 1956 are reported to be satisfactory, and it is at present estimated that they will exceed 400,000 tons. Gross profit on sulphur sales amounted to $1,605,572 after providing $1,788,352 for production, royalty and shipping costs. After deduction of administrative expenses, interest, and expenses on undeveloped concessions, and allowing for income from royalties, etc., net income for 1955 after payment of tax amounted to $378,028.

Earnings during 1955, together with funds from the issue in April 1955 of debentures amounting to $4,651,200 enabled the company to maintain a sound financial position. At the end of the year, net working capital, including sulphur stocks valued at cost, amounted to $5,153,385 after providing for all costs during the year and for capital repayments to the Export-Import Bank and interest on debentures payable in 1956.

TEXAS GULF SULPHUR COMPANY

The barge-mounted Frasch plant to be towed to the Santa Anita dome is at present at Houston on the point of completion, though still awaiting electrical equipment held up by strikes at the works of the Westinghouse Company. At the dome, pipelines are reported to be in position and it is expected that steaming will start in the early autumn.

TEXAS INTERNATIONAL SULPHUR COMPANY

According to a recent announcement by the company, exploratory work in their extensive lease area, which the company is obliged to return to the Mexican Government step by step, has disclosed sulphur reserves totalling

*Estimated output : 30,000 tons.

five million tons. According to Mr. J. B. Eby, the company's geological consultant, only 300 acres out of a total concession area of 126,000 acres have been explored. The company, which in 1954 was engaged in extensive law suits with stock holders, is now reported to have settled all outstanding cases. The company's new president is Mr. Macris, a Mexican national.

Summary

The achievements of the Mexican sulphur industry represented primarily by the impressive output at the Jaltipan dome and the large proved and inferred reserves at other domes have inevitably affected the world sulphur market in the past 18 months. In an address to the New York section of the American Institute of Mining, Metallurgical and Petroleum Engineers at the end of May, Mr. S. Schwartz, president of the New York consulting firm which bears his name, expressed concern at the fierce competition which in his view is already adversely affecting the established U.S. industry. It would seem, however, that in view of the uncertainties of the early production stage, coupled with the depressed world price of sulphur resulting from Mexico's competitive entry into the world markets and the limitation of outlets to little more than marginal tonnages either in the U.S.A. or in U.S. traditional overseas markets, greater anxiety is likely to be felt by Mexican producers, notably those whose production is just starting or is projected for the near future. Bearing in mind that U.S. production, largely as the result of the fruition of Freeport Sulphur Company's development programme and Jefferson Lake Sulphur Company's intensified exploitation, has reached new peak levels, the short-term outlook for Mexican producers is difficult, particularly in view of the strain on the relatively slender financial resources, imposed by the need to stockpile.

Looking further ahead to the time when U.S. Frasch output—failing the start of offshore production—is expected to tail off, it is thought too early to assert Mexico's inevitable ascendancy. It should be borne in mind that one project, San Cristobal, has already encountered serious difficulties and that contrary to the developments in the U.S.A. where exploration and development was effected by many companies, supported by a variety of individual experts, the corresponding work in Mexico has been founded on a relatively narrow basis of opinion and experience.

Over the next three to five years the Mexican industry, if it is to be considered as a reliable world supplier, must prove its ability to maintain an even tenor of production and develop its supply facilities to withstand any surges in demand that may arise. While the port loading facilities at Coatzacoalcos have generally found approval amongst shippers, the movement from dome to port appears to leave room for improvement and expansion, particularly where this, as is the case with Jaltipan sulphur, is dependent on single-line rail traffic.

These sobering thoughts are not intended to detract from the real achievements which have already transformed the Mexican industrial and economic scene, and it is definitely not desired to raise an alarmist note of the possibility of impending failure. On the contrary, the developments in Mexico hold promise of making a vital contribution to the world sulphur industry, and the recent entry of important U.S. financial and engineering interests underlines the widely felt confidence in their success.

Elemental Sulphur in Japan

Production

Output of elemental sulphur in 1955 totalled 202,656 metric tons, an increase of 17,000 tons (9¼%). The number of active producers further decreased, and the above output was contributed by 24 individual mining companies, compared with 28 in 1954 and 36 in 1953.

Details are as follows :—

Producer	*1955*	*1954*
	000 metric tons	
Matsuo Mining Co.	62.3	57.1
Hokkaido Sulphur Co. ...	32.0	27.4
Akan Sulphur Co.	20.0	*
Teikoku Sulphur Co.	17.7	15.8
Shirane Sulphur Co.	11.2	10.8
Zao Mining Co.	9.9	8.7
Nihon Ryutetsu Co.	9.2	9.4
Nihon Sulphur Co.	7.9	17.6
Naruko Sulphur Co.	7.8	*
Atosanobori Sulphur Co. ...	6.1	*
Yamagata Mining Co. ...	5.1	*
Others	13.5	38.9
Total production	202.7	185.7

*Previously included under others.

The reason for the continued reduction of the number of active producers is believed to be due in part to uneconomic mining and refining methods adversely affecting the competitive position of smaller producers, and is also accounted for by the temporary exhaustion of the smaller sublimation deposits, on many of which exploitation was started in the early fifties.

Consumption

During 1955 the high level of activity of Japan's sulphur using industries, in particular of the manufacturers of viscose rayon and pulp, resulted in an increase of 13% in consumption, which amounted to 203,242 metric tons. The further increase in the output of man-made and synthetic fibres has strengthened Japan's position as the second largest producer in the world. Distribution in 1955 was as follows :—

For the manufacture of:	*1955*	*1954*
	000 metric tons	
Carbon disulphide ...	100.9	94.4
Synthetic fibres	5.8	
Pulp	83.1	73.7
Agricultural chemicals ...	2.6	3.5
Ground sulphur	3.7	
Dyes	1.4	8.5
Inorganic chemicals ...	2.4	
Other uses	3.3	
	203.2	180.1

Exports

In spite of the severe domestic supply shortage, particularly during the latter half of 1955, Japan exported 5,792 metric tons under existing contracts, mainly to Australia. In 1954 exports had totalled 7,201 metric tons.

New Industrial Pattern

Early this year an important development took place in the Japanese sulphur industry which fundamentally affected the relations between producers and consumers, and which may have even more important repercussions on Japan's position in the international sulphur trade. Since the cessation of Government price control of sulphur in 1951, the domestic market—constituting virtually the sole outlet for Japanese producers of elemental sulphur—has been extremely sensitive to any changes in demand. The consequent price fluctuations have been violent, ranging from as much as 50,000 yen* in the boom period after 1951 down to 15,000 yen in 1953, when accumulated stocks previously destined for export under International Materials Conference allocations had to be sold on the home market at prices generally below production costs.

The subsequent rapid expansion of domestic requirements, which was not accompanied by a commensurate rise in output, led to a hardening of the domestic sulphur price and, in view of the inadequacy of consumers' and producers' stocks, culminated in an approach by consumers to the Government to authorise imports. Initially, strongly resisted by the producers, an agreement with the consumers was finally reached, in February. This provides for orderly marketing of domestic output at agreed prices, giving producers an assured profit margin of about 15% on the delivered price of sulphur. Based on periodic joint reviews of the supply position, it is foreseen that producers would negotiate individual contracts with consumers of at least six months' duration, and at the same time cease to oppose the imports of sulphur should, as at present, need for this arise. Thus for the year starting in April, 1956, producers receive a price of about 22,000 yen per metric ton f.o.b. mine; one import shipment of about 5,000 tons of U.S. bright sulphur reached Japan in February, and the import of 15,000-16,000 tons is foreseen for the current trading year.

In spite of the existence of vast sulphur resources, which represent one of Japan's most abundant raw materials assets, the existing production facilities are inadequate to raise output to a level which would satisfy demand. High costs due to lack of mechanisation at small mines is paralleled by the impact of higher wage rates and heavy social charges at the larger mines, where some modernisation has been effected. In the absence of financial assistance by the Government, any rationalisation measures in the form of mine and plant modernisation, of new processes, new exploration or exploitation, is left to the individual producers, with the result that the scope for developments is confined to the small number of larger companies who dispose of adequate financial resources. The crux of the present situation appears to lie in the generally uneconomic state of production, which, apart from the shortage of investment capital, discourages established producers from extending their activities.

Virtually the only important development project is that at present being undertaken by the Matsuo Company, who, as one of the prin-

*1,009 yen = £1

cipal mining companies in Japan, has both the capital and the engineering skill to promote its success. It has, however, suffered a temporary set-back, as severe test conditions in a pilot plant disclosed unsatisfactory results in the degree of sulphur recovery, necessitating the re-erection of the furnace with better materials and to an improved design. In consequence the construction of the new plant had to be postponed by one year to 1957, and in order to maintain output at the desired level of 6,000 tons per month the company decided to extend the old plant by the addition of 10 or more sets of old distillation furnaces. Once the new plant comes into operation the old furnaces are to be dismantled step by step.

Modest exports of a few thousand tons annually, mainly to Australia, Burma, and possibly India, continue to be foreseen, primarily for prestige reasons. For the year starting April, 1956, the industry plans to increase its output by 12% to 244,000 tons, a severe task, which may prove to be beyond its capacity. In view of the anticipated domestic use of 246,000 tons, an export commitment of 7,000 tons and the need to replenish stocks by at least 6,000 tons, Japan for the first time in its industrial history will become a sizeable importer of sulphur. As the domestic sulphur demand is conditioned by two industries, rayon and pulp, which are both expanding rapidly, there is a strong indication that under the prevailing condition of sulphur production the need to import will persist and may even rise from the present level. This reversal of Japan's logical role as a large-scale supplier of the Far East and Australasia cannot fail to influence the future pattern of world sulphur supplies.

COMPANY REPORTS

The Tharsis Sulphur and Copper Company Limited

AT the Annual General Meeting, held in Glasgow on 30th May, the Chairman, Mr. W. P. Rutherford, reported the 1955 results of the company, which is one of the world's leading pyrites producers and the second largest in Spain.

Shipments

Deliveries to domestic and export markets totalled 825,472 metric tons pyrites, the highest tonnage achieved by the company in any one year, and 106,000 tons, more than in 1954. The bulk of the additional shipments was however taken up by the Spanish domestic market, where the company is obliged to sell at a fixed and unremunerative price. Following the recently authorised increase in wages this price, after remaining pegged for six years,* was raised by the Government by Ptas. 30, but even now it is not considered adequate.

Production and Development

The current output originates from the Calañas (La Zarza) where development has been carried out down to the 18th floor. The ore mined at this depth retains its impressive dimensions, and the quality of the pyrites. At the Tharsis mine, development work continues at the North Lode open-cast workings, where the company is employing the latest earth moving equipment for the removal of overburden preparatory to large-scale production. Due to heavy rains since last autumn, the development work has been retarded, but already a small output of saleable pyrites is originating from this source.

Exploration work on the Centre Lode, which had been interrupted due to flooding earlier this year, will be resumed this summer, with a view to establishing the extent of cupreous pyrites reserves, the presence of which is indicated by former records.

The company's transportation system, which had been improved during recent years and which is now stated to be in first-class condition, was substantially strengthened by the delivery of four new locomotives. In addition, the pyrites crushing plant at Corrales, situated alongside the company's loading pier on the right bank of the River Huelva, was improved and its capacity increased, and a new mineral deposit for the storage of fine ore, to meet future market demands, was added to the existing storage facilities.

Welfare

To alleviate the effects of the rising cost of living in Spain, which the recently authorised increase of 20% basic wages is helping to compensate, the company is subsidising the sale of

*Ptas 150.50 per metric ton.

food stuffs to their employees at three central stores. Construction of houses for the workers is also continuing, and a church built by the company in the workers' village of Corrales is to be inaugurated this summer.

Finance

Although net profits were £14,807 lower than last year, provision for depreciation was raised by £22,637, and the balance sheet was strengthened by the allocation of £150,000 to the general reserve account. As a result the company's revenue reserves—including surplus from profit and loss account—are now greater than the issued capital. A dividend payment of 12½% on the capital was declared for 1955.

Directors

The company suffered a great loss by the death of its oldest Director, M. Albert J. J. Messéan, who had been a member of the Board since 1903.

Summary

Reviewing his impressions following a visit to the mines, the Chairman assured the meeting that the capacity to mine and transport pyrites was now well above present demand.

Duval Sulphur and Potash Company

Annual Report

PRESENTED by the President, Mr. Geo. F. Zoffman, the Annual Report for the year ended 31st December 1955 shows that the net income derived from sulphur and potash operations was $3,062,827 ($3,071,616 in 1954). Dividend payments remained at $1.25 per share on the issued and outstanding capital stock.

The President confined his report of the company's operations to potash. Approximately $1¾ million were spent on exploring and developing potash resources during 1955. Properties in Eddy County, Mexico, may be further developed, while exploration in the Province of Saskatchewan, Canada, will be resumed when weather conditions permit. Leases, granting options to purchase certain mining claims in Pima County, Arizona, are at present being evaluated.

Review of Sulphur Operations

Approximately one-third of the Company's sales revenues was accounted for by sulphur, the remainder representing sales of potash. It appears that, at least for the time being, no exploration for additional sulphur deposits is being undertaken and that the company is concentrating on developing its potash resources.

Sulphur production at Orchard Dome in 1955 is reported to be 170,900 tons compared with 169,400 for the previous year. It appears that the company's reconstruction programme at the dome has established the economic level of production to be about 170,000 tons compared with about 220,000 tons for the years 1949-1953 and about 185,000 tons during the period 1940-1948. Since 1938 Orchard Dome has yielded a little over 3.4 million tons of sulphur.

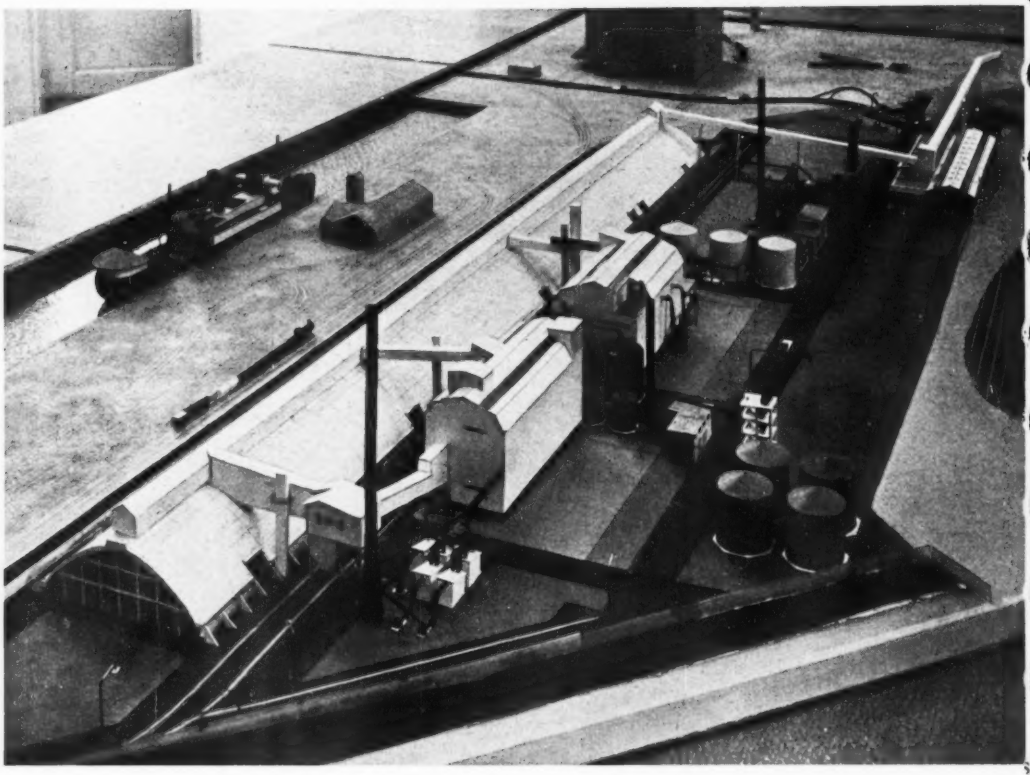
Current Events

UNITED KINGDOM

Major Fertilizer Project

Scottish Agricultural Industries Limited, one of the leading acid/fertilizer manufacturers in the United Kingdom, are engaged on a £3 million development project. The main feature is the construction of a new plant at Leith which, embodying the latest methods in sulphuric and phosphoric acid production, fertilizer compounding and granulation, will permit large-scale manufacture of high concentrate fertilizers. Among these will be ammonium phosphate which hitherto has not been produced in the United Kingdom.

The project includes three process plants. First, the sulphuric acid plant, which, burning elemental sulphur, is designed to produce 175 tons per day (100% H_2SO_4) in a Monsanto type contact converter. It is being built by Simon-Carves Limited, incorporating heat exchange equipment to produce high pressure steam at 17,000 lbs/hour. The second process plant will react phosphate rock with sulphuric acid by the Prayon process to produce phosphoric acid. The phosphoric acid magma will be subjected to vacuum filtration for the extraction of waste gypsum slurry. The finished fertilizers will be produced in the third process building to which will be



Model of New Fertilizer Plant at Leith.

delivered the phosphoric acid and various other raw materials required for the manufacture of concentrated fertilizers, including ammonium phosphate. This unit has been designed by Dorr-Oliver Inc., of Stamford, U.S.A., and is being constructed by Simon-Carves Limited.

New dockside discharge facilities are being installed by the Leith Dock Commission, which will comprise 3 grabbing cranes capable of unloading at the rate of 350 tons per hour. To ensure economical handling, the raw materials will be carried by a conveyor, housed in an overhead gantry from the dockside to the end of the storage shed. This store is one of the main features of the site and is capable of holding 56,000 tons. It is 907 feet long, 100 feet wide and 41 feet high.

The site, ideally located between a deep water berth to the west and a large railway marshalling yard to the south-east, has been reclaimed by the Leith Dock Commission from the Firth of Forth. Waterside construction works include a screening chamber which will process up to 180,000 gallons per hour of dock water to be used for cooling and other process requirements. To date, 12 of the 19 acres planned for the site have been reclaimed and tipping is still in progress. The storage shed is now nearing completion, while it is anticipated that the sulphuric acid plant will be ready for operation in August.

Acid Plant to Close

As the result of the cessation of oil shale operations at the Roman Camp Works (West Lothian) of *Scottish Oils Limited*, a subsidiary of British Petroleum Company, it has been decided to close the company's acid plant at Bathgate later this year. Based on the use of lump pyrites this chamber acid plant had an annual capacity of about 9,000 tons. At Broxburn, where the company has similar facilities, the use of lump pyrites has been reduced by about 70% and acid manufacture is now based primarily on the use of elemental

sulphur recovered from the tail gases of the catalytic cracker at the B.P. Refinery at Grangemouth. Currently, acid output is at a rate of 1,000 tons per month.

Acid Plant to Restart

At the Company's annual general meeting in May, Mr. F. E. F. Blythe, chairman of *William Blythe & Co.*, announced that on the recommendation of the company's technical sub-committee, operation of the company's sulphuric acid plant at Hapton, Lancashire, is to be resumed shortly. Completed in 1954, the 33,000 tons (100% H_2SO_4) plant, which is based on the use of pyrites in a Badische Anilin and Soda-Fabrik turbulent layer roasting plant, had been operated for a very brief test period only, as adequate acid supplies in the area did not offer an outlet for its production.

The chairman's indication that "other plants and enlargements for new production at Hapton were well advanced" points to the probable captive use of the sulphuric acid output. The company, who are prominent chemical manufacturers in the United Kingdom, also operate a sulphuric acid plant at Church, Lancashire, which is based on the use of elemental sulphur.

EIRE

Exploitation of Avoca Sulphide Ore Deposits

Early this year, following successful exploration by Irish Copper Mines Limited of the Avoca copper - lead - zinc - sulphide ore deposits, *St. Patrick's Copper Mines Limited*, a wholly owned subsidiary, has announced plans to exploit this property. The deposit, 40 miles south of Dublin, has been mined at various intervals. Drillings, sponsored by the Eire Government, indicated four bodies of complex sulphide ores, totalling about 14 million tons. The largest deposit is estimated at 9 million tons, averaging 1.07% copper, while two other deposits, each of approximately 2½ million tons, average 1.3% copper. The fourth is believed to contain ½ million tons of lead and zinc ore.

Development work by Irish Copper Mines Limited, a Toronto registered company and an associate of the Mogul Mining Corporation, Toronto, commenced on 1st October 1955, and further drillings have indicated that total deposits at Avoca may be as large as 20 million tons. Plans for mining the ore consist of driving an inclined shaft to a depth of 650 feet below sea-level with sub-levels cut at intervals of 60 feet.

It has recently been reported in Toronto that Mogul Mining Corporation is to advance to Irish Copper Mines some $7 million through a debenture issue, with the right to subscribe to 1¾ million shares of the Irish Copper Mines Limited at $3 per share. This will allow the mine to be put into production at an early date and together with the action of the Eire Government in exempting the company from income tax and corporation profits for the first four years of operation, should establish the company on a firm financial basis.

St. Patrick's Copper Mines Limited plan to build a mill with a throughput capacity of 4,000 tons of ore per day and anticipate an annual production of 120,000 tons of pyrites concentrates and 40,000 tons of copper concentrates.

CANADA

Jefferson Lake Sulphur Recovery Project

Early in May an agreement was concluded between Jefferson Lake Sulphur Company and Pacific Petroleum Limited for the joint construction and operation of a $1.8 million sulphur recovery project plant close to the latter's projected installations near Fort St. John, British Columbia. As reported earlier* Pacific Petroleum Limited are building an $18 million processing plant for the removal of hydrogen sulphide and liquid hydrocarbons from natural gas which is to be piped from the Peace River area of Alberta through British Columbia to north-west U.S.A.

The sulphur recovery plant will process the concentrated hydrogen sulphide extracted by the amine process from the crude natural gas and produce recovered elemental sulphur of high purity at a rate of about 300 tons per day. It is envisaged that the new plant will enter production by 1st October, 1957. The large potential gas reserves of this area, coupled with the rapidly expanding economy of the north-west may lead to production being doubled within the next five years. Plans are now in hand for the construction of a rail link to the existing rail facilities which will permit easy transportation of sulphur into

*See Quarterly Bulletin No. 12, Page 38.

the States of Washington and Oregon, the Vancouver area, and from Vancouver to export destinations such as the Far East.

The extension outside the U.S.A. of the interests of Jefferson Lake Sulphur Company marks an important step in the Company's expansion programme which the President, Mr. Eugene H. Walet, Jnr., expects will prove sound and profitable. The Company's experience in operating sulphur recovery units and marketing sulphur are undoubtedly a valuable asset in this new venture.

Sulphuric Acid for Titanium Dioxide Plant

The $15 million project of *Canadian Titanium Pigments Limited*, now under construction at Varennes, Quebec, and scheduled for completion in the spring of 1957, will include facilities for the manufacture of sulphuric acid.

A Monsanto contact acid plant of standard design is to be installed by the Leonard Construction Company of Chicago and based on the use of elemental sulphur, it will have a capacity of 150 short tons per day of 100% H_2SO_4. Production will be in the form of either 98% acid or 66° Bé.

It is understood that the raw material requirements will probably be met in the form of dark sulphur which may be obtained either from Mexico or the U.S. Gulf Coast area, dependent on prices and freight rates. Shipments will be unloaded either at Montreal, which is about 15 miles south-west of Varennes, or at Sorel, Quebec, about 40 miles downstream from the plant on the St. Lawrence River, from where it will be delivered to the plant by rail.

It will be Canada's first plant for the manufacture of titanium dioxide and the sulphuric acid produced is intended solely for captive consumption in the pigment plant. The company is a subsidiary of the National Lead Company of New York.

INDIA

Sulphur Exploration

In view of the anticipated large increase in sulphur requirements which should accompany the expansion of industrial activity in India in the coming years, the Indian Government is concerned with the inadequacy of indigenous sulphur supplies and the growing dependence on imports of elemental sulphur.

Apart from a number of projects which may result in the recovery of sulphur from smelter, oil refinery and other industrial gases it is reported that the Amjor pyrites deposits*, containing about 40% sulphur will be re-examined when drilling-rigs become available. It is also understood that Sir J. C. Gosh, of the Planning Commission of the Government of India, is sponsoring an expedition to "Barren Island" and "Narcondam" about 100 miles east of the Andaman Islands, where it is anticipated that volcanic deposits of sulphur will be found. As these islands are uninhabited the expedition party, consisting of two or three geologists, will have to be based on the Andaman Islands.

It is reported that the exploitation of the Ladakh sulphur deposits in Kashmir may become practicable before long as new road construction is scheduled to open up this region.

UNITED STATES

Integrated Sulphuric Acid Plant

The *Kennecott Copper Corporation* is undertaking a $4.7 million expansion scheme at their concentration mill at Hayden, Arizona. Due for completion in February 1957, the new Leach - Precipitation - Flotation plant will include a pyrites flotation unit, a Dorr Fluo-Solids roaster and a contact sulphuric acid plant. The plant is being erected by Western Knapp Engineering Company of San Francisco to the design and with equipment supplied by Chemico.

The sulphide tailings arising from the flotation of the Ray Mines' sulphide-copper ore, which have hitherto been dumped, will be subjected to further flotation to yield pyrite concentrates which, after roasting, will produce sulphur dioxide gas and iron calcine. The sulphur dioxide gas will be converted to sulphuric acid in a 100 tons per day contact acid plant. It is estimated that approximately 80 tons acid per day will be used to leach oxide copper ore, the remainder being used to leach waste dumps. The iron calcine will be mixed with powdered coal and reduced to sponge iron.

The copper dissolved in the leaching of the oxide copper is to be precipitated with sponge iron and the resultant concentrate recovered and dispatched for smelting together

*See Quarterly Bulletin No. 5, page 7.

with the sulphide-copper concentrates produced from the old section of the plant. The treatment facilities of the Leach-Precipitation-Flotation plant will enable the company to exploit substantial ore reserves of sulphide-copper ore which due to an oxide coating was hitherto not amenable to treatment by flotation. One of the features of the process is the application of acid leaching to much smaller sized particles than practised elsewhere. At the current rate of output, it is estimated that copper recovery will be increased by 12% representing 5,000 tons of metallic copper annually.

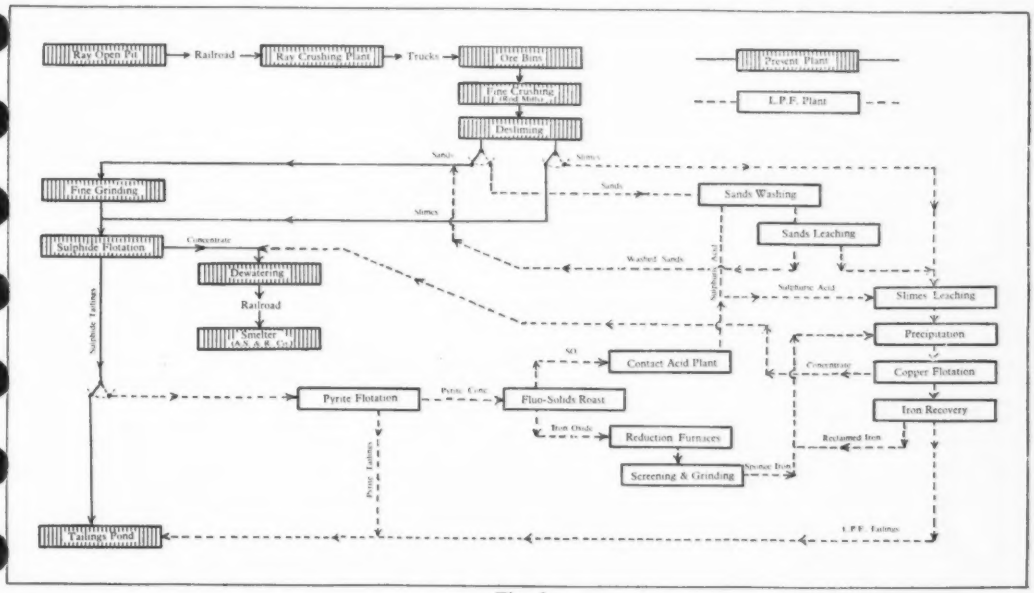


Fig. 6.

The flowsheet shows the integration of the new plant with existing facilities for the treatment of sulphide copper ores. The recovery of approximately 80 tons per day of pyrites concentrates hitherto wasted, represents a new supply of sulphur at a rate of approximately 12,500 tons per annum.

Transfer of Chemical Construction Corporation

In a joint statement, issued on 18th April, Mr. K. C. Towe, President of the American Cyanamid Company, and Mr. George Walker, President of the Electric Bond and Share Company, announced the imminent transfer of the *Chemical Construction Corporation*, hitherto a subsidiary of the American Cyanamid Company, to the *Electric Bond and Share Company*.

Chemico are one of the most prominent chemical plant engineers in the world, specialising in installations for the manufacture and concentration of sulphuric and nitric acid, recovery of waste acids, manufacture of synthetic ammonia, urea, methanol, acetylene from natural gas, phosphatic and nitrogenous fertilisers, and sulphur refining of native ores. Amongst sulphuric acid and sulphur projects engineered by Chemico are the following:

The 100 tons per day sulphuric acid contact plant based on the use of sulphur in by-product pyrites for Kennecott Copper Corporation at Hayden, Arizona, which is being erected by Western - Knapp Engineering Company of San Francisco to the design and with equipment supplied by Chemico.

The 75 tons per day contact sulphuric acid plant based on the use of elemental sulphur for Shawinigan Chemicals Limited, which Chemico will design, equip and construct.

The 200,000 tons per annum triple superphosphate plant to be built to

Chemico's design in co-operation with Dorr-Oliver, Inc., for the American Cyanamid Company. Due to be completed by mid-1957, the new plant is sited at Brewster, Florida, the centre of the company's phosphate ore-mining operations.

Four sludge acid recovery plants with an aggregate capacity of ½ million tons acid (100% H_2SO_4) are due to be completed this year for Consolidated Chemical Industries, of Houston, Texas. A notable feature of these installations is the use of the fuel value of the sludge, which appreciably reduces the supplementary fuel requirements of the operation.

A sulphur-refining plant for Sominar, Argentine, built at an altitude of 10,000 feet above sea-level; treating native ore containing about 50% sulphur, by the Chemical Construction Corporation refining process, it is due to commence operations this year.

Plant installed by Chemico represent about 29% of the world's ammonia production capacity, and about one-third of the world's sulphuric acid capacity.

The new association between Chemico and Ebasco Services Incorporated, the wholly owned subsidiary of Electric Bond and Share Company, is, according to Mr. Walker, expected to be particularly advantageous as the two companies' talents and experience are complementary. Ebasco, who have been engaged in engineering and construction work for the utility industries for the past 50 years, and in civil engineering for the past 13 years, has, like Chemico, been active in every continent in the world. It is foreseen that Chemico's services to industry are to be strengthened and expanded, particularly in the field of organic chemicals. At the same time, Mr Towe announced that American Cyanamid Company has formed an Engineering and Construction Division, under General Anthony C. McAuliffe, retiring Commander-in-Chief, U.S. Army Forces in Europe, as General Manager. This division will be responsible for the planning and operation of all major Cyanamid engineering projects.

New Sulphuric Acid Plants

Allied Chemical and Dye Corporation, General Chemical Division, plan to build a sulphuric acid plant on a 120-acre site at Elisabeth, New Jersey, fronting on Newark Bay. The company's announcement that the "new facility would be equipped for processing raw materials supplied by Esso Standard Oil Company from its Bayway refinery, and for returning finished products to Esso" points to the possibility of acid output being based on recovered hydrogen sulphide.

The expansion project at the company's East St. Louis, Ill., plant, which foresaw a 35% increase in acid output, was completed recently. The new facilities include a spent-acid decomposition unit to recover sulphur from oil refinery sludge.

To meet the growing industrial and agricultural requirements for sulphuric acid in the expanding economy of California, the *Stauffer Chemical Company* is to start immediately the construction of a 200 tons per day acid plant at Dominguez, California. Based on the use of elemental sulphur, acid will be made in a direct conversion unit employing the company's own vanadium catalyst. Production is expected to commence in July, 1957.

Sited in the Newark Bay area, and due to be completed this year, *Dixon Chemical and Research Incorporated* of Clifton, New York, are building a brimstone based contact sulphuric acid plant with a daily capacity of 400 tons (100% H_2SO_4).

FINLAND

New Sulphuric Acid Plant

Early this year *Rikkihappo - ja Superfosfaattitehtaat Oy*, Helsinki, one of the largest chemical enterprises and the only sulphuric acid manufacturer in Finland, started up its new sulphuric acid plant at Harjavalta. The new plant is based on the use of sulphur contained in the exit gases of the copper smelter of the Outokumpu Oy, and the conversion of SO_2 gases takes place in a Petersen tower, which has a rated daily capacity of 200 tons acid (100% H_2SO_4). The construction of the new plant was determined by the arising of excessive quantities of sulphurous exit gases, part of which are already converted to sulphuric acid in a contact plant built in 1947 which has a rated capacity of 250 tons per day. The acid output of the new plant will, like that of the existing plant, be used in the manufacture of superphosphate, which in consequence will be raised from 120,000 tons to 200,000 tons per annum.

GREECE

New Fertilizer Plant

The Hellenic Company of Chemical Products and Fertilizers, whose installations at the Piræus are one of the largest and most modern in the Eastern Mediterranean, has recently started operation of a 100 ton per day fertilizer plant, built by Dorr-Oliver Inc. for the manufacture of triple superphosphate or ammonium phosphate. Currently producing ammonium phosphate, the new installation replaces the 40 tons per day superphosphate plant originally installed in 1934. Available sulphuric acid capacity, which is based on the use of pyrites from the company's Hermione and Kassandra mines, is adequate to meet the increased requirements of the new operations.

TURKEY

New Pyrites Production

Following the conclusion of an agreement with an American firm, the Turkish Government has authorised the exploitation of the extensive pyrites deposit of *Kure*, 18 miles inland from the Black Sea port of Inebolu. The planned capacity of the mine is 100,000 tons pyrites annually of which about one-quarter will be required for acid manufacture at the nearby plant of Sumer Bank. The balance of about 75,000 tons will be available for export, which will reimburse over a period of three years the U.S. supplier of mining equipment valued at $1.2 million. The Kure deposit is a massive pyrite lens of which 1.6 million tons has been proved and which is understood to have probable reserves in excess of 10 million tons ore. The pyrites contain 48% sulphur, 1.6-2% copper, and about 1½ grammes per ton gold.

JAPAN

New Pyrites Deposits

A new pyrites deposit at Abuta, said to be the largest of its kind in Japan, has been developed by the *Nittetsu Mining Company*. Estimated to contain at least 20 million tons high grade pyrite, exploitation is due to commence this summer. At the Ryou mines an important new deposit of iron sulphide ore rich in germanium, has been discovered and development work is progressing.

Pyrites production in Japan in 1955 amounted to 2,735,662 metric tons—containing an average of 42.2% sulphur—the largest output in the world.

CHILE

Sulphur Production and Consumption—1955

Under the stimulus of compensatory commodity transactions with European countries, the production of elemental sulphur in 1955 rose to 67,000 tons, an increase of over 60% compared with output in 1954. *Società Azufrera Aucanquilcha*, the largest producer, maintained its share of about 38% of the total output. Amongst the other producers, the most striking results were achieved by *Azufrera Polan*, whose output increased from 5,000 tons to over 12,000 tons. The company is the only one in Chile not using autoclave refining, and in consequence its sulphur operations which are based on a solvent (carbon disulphide) extraction process and plant developed by Zahn & Co., of Hameln, Germany, are the most efficient in Chile. Domestic sales of sulphur continued to increase and in 1955 amounted to about 26,000 tons, distributed as follows :—

	tons
Agriculture	4,000
Rayon	5,400
Explosives	5,500
Sulphuric Acid ...	7,600
Chemicals	2,000
Miscellaneous ...	1,500
	26,000

During 1956 domestic consumption is expected to increase about 15% to 30,000 tons. Exports in 1955 totalled 47,227 metric tons.

U.S.S.R.

Investigations into Rubber Vulcanisation

The function of sulphur and sulphur compounds in rubber vulcanisation were recently examined by W. J. Prjadilowa with the aid of the radio-active sulphur isotope S-35. The experiments, which were conducted in an oxygen-free atmosphere of pure argon gas, were designed to determine means of reducing the quantity of sulphur and its compounds used in rubber vulcanisation. It was found that the thiuram accelerators split into radicals, resulting in the formation of an unstable sulphur radical S_2, which plays a significant part in vulcanisation.

Statistical Appendix

Norway

PYRITES PRODUCTION

thousand metric tons

Average	1900-1904	113.6	1942	836.2	1929	0.8	1943	91.8
"	1905-1909	239.6	1943	822.5	1930	1.6	1944	66.7
"	1910-1914	403.9	1944	762.9	1931	6.5	1945	21.8
"	1915-1919	357.5	1945	251.5	1932	46.9	1946	71.9
"	1920-1924	347.8	1946	548.8	1933	59.9	1947	82.4
"	1925-1929	670.9	1947	731.6	1934	64.8	1948	79.2
"	1930-1934	728.7	1948	747.3	1935	66.2	1949	81.2
	1935	893.5	1949	756.9	1936	64.8	1950	96.2
	1936	1,031.8	1950	760.7	1937	97.2	1951	98.4
	1937	1,048.3	1951	707.1	1938	76.6	1952	104.8
	1938	1,027.8	1952	712.6	1939	90.7	1953	103.3
	1939	1,106.2	1953	744.9	1940	77.9	1954	100.7
	1940	762.3	1954	794.9	1941	78.7	1955	100.4
	1941	948.5	1955	831.0	1942	78.7		

ELEMENTAL SULPHUR PRODUCTION

thousand metric tons

PYRITES EXPORTS

metric tons

	1953	*1954*	*1955*
Poland	15,489	27,940	9,681
Czechoslovakia	22,477	2,100	14,442
Eastern Germany	58,290	64,087	70,735
Western Germany	80,375	131,008	160,955
Sweden	66,545	78,467	96,608
Belgium & Luxembourg	2,200	—	—
Denmark	66,170	61,200	77,169
France	11,349	33,968	22,542
Holland	5,186	4,207	5,732
United Kingdom	—	18,680	14,790
	328,081	421,657	472,654

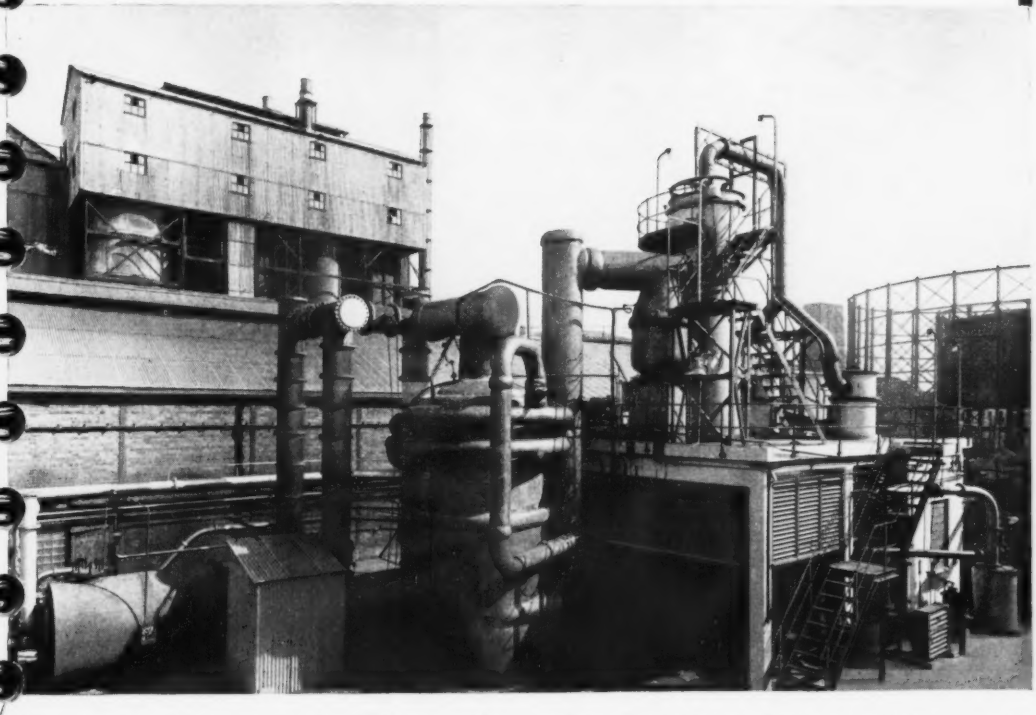
SULPHUR EXPORTS

metric tons

	1953	*1954*	*1955*
Finland	20,505	42,727	30,181
Sweden	29,178	39,662	48,587
Western Germany	2,187	—	—
Belgium & Luxembourg	751	—	—
Denmark	126	—	245
France	4,595	3,036	—
Australia	8,534	9,259	—
United Kingdom	—	1,300	—
Spain	—	2,975	—
Others	—	300	37
	65,876	99,257	79,050

WET CONTACT PLANTS

for sulphuric acid production from hydrogen sulphide



Wet contact plants are an efficient and economical means of producing sulphuric acid from H_2S gas, which may be derived from ammonium sulphate saturators or from liquid purification of coal gas.

In the latest Huntington Heberlein plants, maintenance costs are reduced by using acid-irrigated towers and mist precipitation equipment for the acid condensation in place of the tubular condensers of earlier plants, and capital cost is reduced by replacing the electro-precipitators formerly used for acid mist precipitation by simple mechanical ceramic tube filters. These features are incorporated in the plant shown, which was recently built at the Birmingham works of Brotherton & Co. Ltd., to produce 10 to 12 tons per day of 78 per cent sulphuric acid.

In suitable cases a waste heat boiler may be used as a gas cooler between the H_2S combustion chamber and the convertor.

Wet contact sulphuric acid plants by

Huntington, Heberlein & Co Ltd

SIMON ENGINEERING GROUP

SIMON HOUSE, 28-29, DOVER ST., LONDON, W.1. Tel : Hyde Park 8191. Grams : Innovation, Wesphone, London

COMMONWEALTH REPRESENTATIVES | Simon-Carves (Africa) (Pty) Ltd : Johannesburg Simon-Carves (Australia) Pty Ltd : Botany, N.S.W.

WH.20

S = $

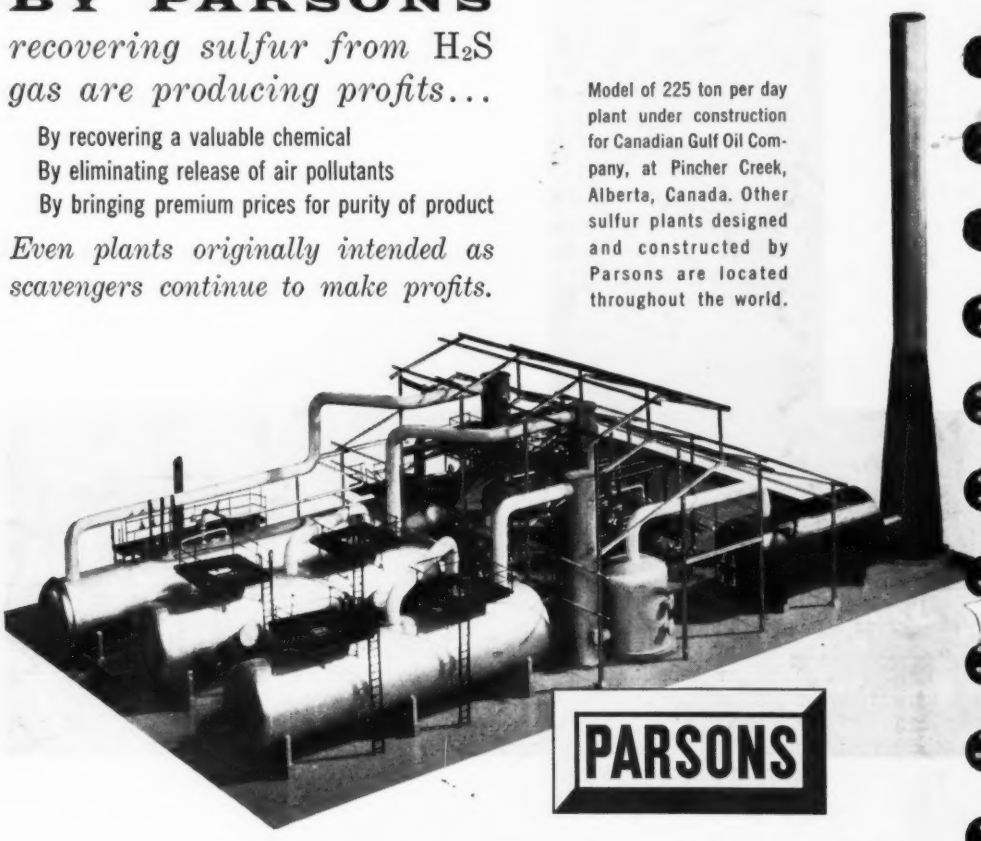
30 PLANTS BY PARSONS

recovering sulfur from H_2S *gas are producing profits...*

By recovering a valuable chemical
By eliminating release of air pollutants
By bringing premium prices for purity of product

Even plants originally intended as scavengers continue to make profits.

Model of 225 ton per day plant under construction for Canadian Gulf Oil Company, at Pincher Creek, Alberta, Canada. Other sulfur plants designed and constructed by Parsons are located throughout the world.



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